54

F.O.B.
U.S.A.
Uncle Sam has a lot of packages these days for Hirohito, Adolph and his stooge Benito — so important they're being delivered by air so we won't keep the boys waiting! It will take huge quantities of gasoline to terminate the Axis . . . Hanlon-Buchanan is ready with Butanes and Stabilized Natural Gasoline — STA-VOL-ENE the "Natural" known throughout the World.
STA-VOL-ENE
STABILITY ◆ VOLATILITY ◆ ENERGY
IT'S A "NATURAL"

Hanlon-Buchanan Inc

PIONEER NATURAL GASOLINE MANUFACTURER

EXPORT TERMINALS:
Goodhope, La. Corpus Christi, Tex.
Houston, Texas Texas City, Texas
Barbours, Texas Galena Park, Texas

TULSA, OKLAHOMA
NATIONAL BANK OF TULSA BUILDING
PHONE 4-1101 or L.D. 398 WIRE — OR WRITE P. O. BOX 1559
Cable Address . . . STAVOLENE, Tulsa, U. S. A.

FOREIGN REPRESENTATIVE
Banks, Williams & Co., Ltd.
4 Lloyd's Ave.
London, England

WORLD PETROLEUM

Incorporating Petroleum Equipment Exporter

THE MANAGEMENT PUBLICATION OF THE INTERNATIONAL PETROLEUM INDUSTRY

VOLUME 13 | AUGUST, 1942 | NUMBER 9

CONTENTS

Congressional Muddling 21

"Quick Rubber" Campaign 22

Legal Aspects of Scrap Collection . . . 26

Fuel Vaporizer 28

Electrification of Plantation Pipe Line . 30

Diesel-Gas Compressor at Luby, Texas . 36

California Heavy Oil Production . . . 38

Abstracts 44

Rex W. Wadman
General Manager

E. W. Mayo
Editor

E. W. Mayo, Jr.
Managing Editor

Jack Selden
Art Director

COPYRIGHT

COPYRIGHT, 1942, by the estate of Russell Palmer. Contents may not be reproduced without permission.

CORRESPONDENCE

ADDRESS all correspondence regarding editorial, advertising and subscription matters to 2 West 45th Street, New York, N. Y. Telephone Murray Hill 2-7333.

Published monthly by the estate of Russell Palmer, 34 Crystal Street, East Stroudsburg, Pa.

London office: Brettenham House, Lancaster Place, W.C.2.

Pacific Coast office: Don F. Harner, 1595 Pacific Avenue, Long Beach, California. (Tel.: 613-238)

SUBSCRIPTIONS

Annual subscription is offered at the flat rate of $5.00 (U.S.) postpaid Single copies are obtainable at 50 cents

Small steam rig near Jena, La.
Photo by Ulric Meisel

EDITORIAL

CONGRESSIONAL MUDDLING THREATENS NATIONAL EFFICIENCY

IN spite of all the confusion that has arisen from the discussion of synthetic rubber for war purposes certain fundamental facts are not to be overlooked. The production of butadiene and styrene as the raw materials for the manufacture of buna type synthetic rubber offers no serious difficulties. The sources from which they can be obtained are numerous and ample. The processes are fully worked out and are being carried on in plants that have been in operation for a considerable time. The real bottleneck, so far as one exists, is in providing the materials of construction for large plants capable of the greatly expanded output necessitated by war requirements. This is the crux of the entire war program. Production has expanded at a rate far beyond expectations and has been using up metals and machinery faster than they can be replaced. It is because of this situation that the action of Congress in voting to set up a so-called Rubber Supply Agency, taken, it may be noted, without a quorum both in the Senate and House, is particularly threatening. It confers authority upon the director of the Rubber Supply Agency to purchase or construct plants and equipment for the processing of rubber and the production of alcohol from farm or forest products for conversion into rubber making materials; moreover it states specifically that he can demand and must receive priority ratings for "any article or material needed for the purposes of this act" and that delivery of such material "shall have priority over all deliveries of similar article or materials for private account." The purpose of the act as stated in Section 4 is to provide an adequate supply of alcohol produced from agricultural products "to meet any military or civilian need of alcohol in the United States."

This extraordinary piece of legislation seeks its justification in a report of the Senate Committee on Agriculture which in turn is based upon hearings conducted by a sub-committee under the chairmanship of Senator Gillette of Iowa. Its main thesis is that in setting up a program for the production of synthetic rubber for war use the possibilities of using farm products for conversion into alcohol for butadiene were entirely disregarded and it states as "the only possible explanation" of this that the dollar-a-year men in the chemicals branch of the War Production Board were fearful of post war competition from industrial alcohol for companies with which many of these officials had been associated.

Against these assertions stand the facts that out of a war program for 700,000 tons of buna rubber the material for something over 200,000 tons is to be obtained from alcohol. As the situation now stands the plans approved by the War Production Board call for the use of some $80,000,000 worth of grain, $22,000,000 worth of petroeum gases and about $10,000,000 worth of benzol from coal in effectuating the projected output of buna rubber. It was stated recently by the director of the alcohol section of the Chemicals branch of the War Production Board that the production of alcohol during 1943 from the plants now in existence will be more than sufficient to provide all the alcohol required for direct war purposes plus the 200,000,000 gallons earmarked for the synthetic rubber program. Moreover the "quick" rubber campaign described elsewhere in this issue promises to bring into operation by the end of the year a yearly productive capacity of 200,000 tons of butadiene which will be in addition to the war program and will provide rubber for civilian use. This is to be obtained from existing refineries with little or no use of critical materials. While the act as drafted avoids direct interference with existing contracts for war production of butadiene it authorizes the construction and equipment of plants for experimental purposes or for the production of unneeded alcohol and demands the assignment to such uses of large quantities of precious structural steel, steel plate, copper and bronze that must be taken from the dwindling amount of these materials that remains available for the use of the country's essential industries. It is a blundering attempt by Congress to dictate the method of carrying out a task that should be left in the hands of men with technical knowledge and experience. Most serious of all it is an attack on the principle of concentrated control on which the success of the war effort depends.

"QUICK RUBBER" CAMPAIGN Under Way

To Meet Civilian Transport Needs

"Progress toward the production of 'quick' butadiene is extremely gratifying", said Wright W. Gary, director of the refining division of the Office of Petroleum Coordinator on his return to Washington, June 29, from a rapid swing around the country. "It is safe to say that capacity for 200,000 tons annual production will be in operation by the first of the year." More than 300 refiners, he estimated, have attended meetings of district committees and subcommittees looking to squeeze maximum production from existing facilities in the shortest possible time, while OPC has distributed 7500 copies of reports describing methods which may be used. Some 30 nucleus plants are being prepared for butadiene production but at least 75 percent of the refining industry will contribute. "It should be noted," Mr. Gary added, "that the program includes the production of benzol and toluene which will help the manufacture of TNT as well as a considerable amount of Flexon or so-called bathtub rubber."

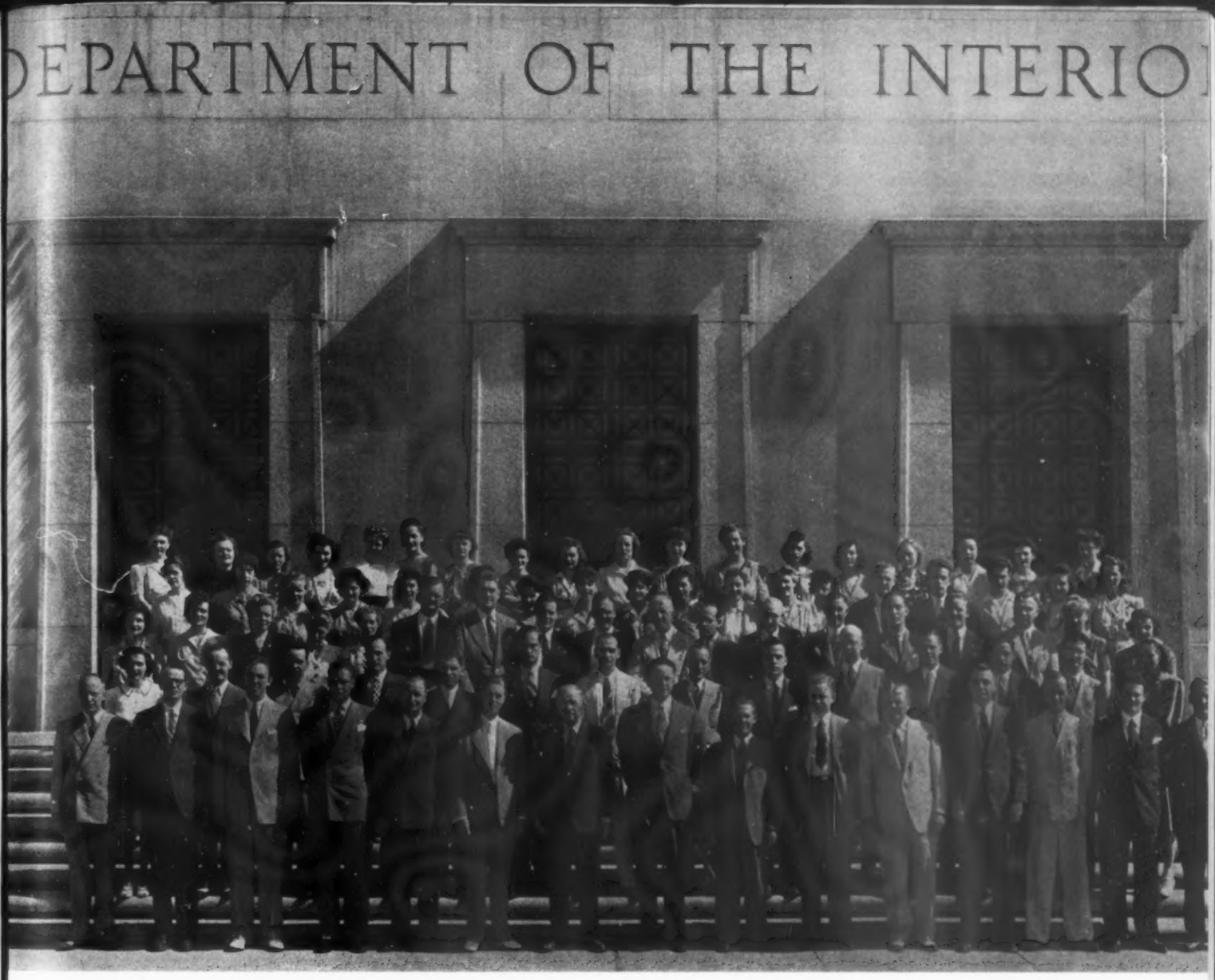
OUT OF THE welter of claims, counter claims, disputes, allegations and Congressional political maneuvering which has befogged the rubber situation some light has begun to emerge. This applies both to the present status and future prospects of the government's rubber program and to the possibilities, in addition to that program, of providing by various means sufficient substitute materials to maintain essential motor transportation during the next two years while plants now building or authorized are getting into operation.

Several developments have contributed to this clarification. Apparently in answer to Congressional charges that the War Production Board and Rubber Reserve Corporation had made no real progress toward providing an adequate supply of synthetic rubber the latter company made public a list of the plants now in course of construction for the manufacture of materials to be used in the making of synthetic rubber and for the fabrication of the rubber itself. The statement included the capacity of the plants, the names of the companies that have contracted to build and operate them and the dates set for their completion. It showed that twenty plants will be devoted to the production of nearly 600,000 long tons of butadiene of which approximately 200,000 tons will be derived from alcohol. Thirteen plants to be operated by chemical companies will supply 200,000 tons of styrene. Thirty plants to be managed by rubber companies will convert these materials into 700,000 tons of rubber. Three plants were listed for the production of 60,000 tons of butyl rubber and to three others was assigned the output of 40,000 tons of neoprene. Of the total number of plants covered by the statement nine, with a combined capacity of over 100,000 tons of butadiene, styrene, butyl rubber and neoprene are scheduled to be in operation by January 1943. The remainder are due for completion at various dates extending to October, 1943. The thirty rubber manufacturing plants will be completed at corresponding dates in time to manufacture the raw material.

With members of Congress looking on, Dr. Per K. Frolich, president-elect of the American Chemical Society and head of the Esso laboratories, staged a small-scale demonstration of the actual manufacture of synthetic rubber of the butyl and buna-S types at a hearing of the House Mines and Mining Sub-committee. Dr. Frolich is shown in center of picture, with two of his associate technicians, Dr. William J. Sparks, left, and Robert McKee Thomas.

This was the government's war program as it stood on July 17 when the statement was put on record before a Congressional sub-committee. It does not include the output of privately owned plants now producing at the rate of 25,000 tons yearly which will be raised to twice that amount by the end of the year. The government however is buying their output on contract. At the time when the statement was submitted it was announced that work on one plant of about 50,000 tons yearly capacity had been suspended pending an investigation to determine whether a saving in the amount of critical materials required for its construction could be effected by adoption of the Houdry process. Since this statement was issued an important change has been made in the butyl rubber program which will raise yearly production from 60,000 to 132,000 tons. The nature of this change was explained following the War Production Board's announcement of the revision, by W. S. Farish, president of Standard Oil Company (New Jersey) which originated the butyl process. Through improvements in the process of manufacture, Mr. Farish explained, including the addition of carbon black to the raw material in process and changes in technique to cut down the recycle load and get a greater use of equipment, it had been found possible to raise the designed capacity of five butyl plants under construction by Standard Oil of Louisiana and Humble Oil and Refining Company from the 60,000 tons originally contemplated to 192,000 tons with an addition of only 27 percent to the investment. The government, however, asked the companies to balance the program by determining the capacity that could be reached without requiring any additional materials of construction. The resulting estimate was that capacity could be raised to 132,000 tons without added cost or materials and with a consequent reduction in the unit cost of production of about five cents per pound. This made it possible to eliminate one of the units originally provided for.

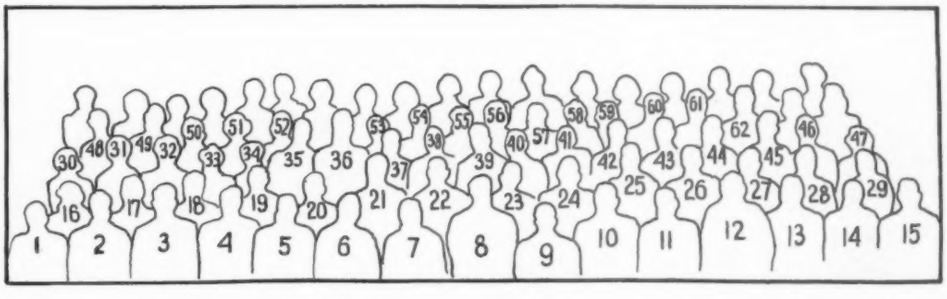
With this change and with reinstatement of the one plant contract now in suspense the annual



Members of the Refining Division of the Office of Petroleum Coordinator: 1. James Costello, Principal Specialist, tetraethyl lead; 2. Dr. M. R. Mandelbaum, Principal Specialist, hydrocarbon chemicals; 3. Arthur Danner, Principal Contract Negotiator, defense plants; 4. R. B. Cragin, Assistant Director of Refining; 5. Wright W. Gary, Director of Refining; 6. R. K. Davies, Deputy Petroleum Coordinator; 7. Harold L. Ickes, Petroleum Coordinator; 8. B. K. Brown, Assistant Deputy Petroleum Coordinator; 9. P. M. Robinson, Assistant Director of Refiring; 10. G. L. Parkhurst, Chief, New Facilities Section; 11. M. B. Miller, Chief, Construction Section; 12. D. W. Wilson, Technical Consultant; 13. W. W. White, Aviation Consultant, Aviation Gasoline Allocation Board; 14. J. H. F. Leonard, Principal Attorney assigned to Refining Division; 15. E. J. Green, Administrative Assistant; 17. H. A. Stiles, Principal Specialist, Refinery Operations; 18. R. L. Speer, Specialist, Gasoline and Distillate Fuels; 19. G. H. Skerritt, Senior Analyst, aviation gasoline; 20. Rubin Werlin, Principal Contract Negotiator, privately owned facilities; 21. E. A. Dingee, Analyst, aviation gasoline; 22. L. A. McVey, Recording Secretary Aviation Gasoline Allocation Board; 23. G. A. Norris, Senior Statistical Clerk; 24. J. P. Withers, Senior Specialist, hydrocarbon chemicals; 25. R. P. Horner, Specialist, lube oils, waxes, greases; 26. N. E. Birch, Contract Negotiator; 27. V. E. Sicks, Equipment Expediter; 28. J. E. Hughes, Engineer; 35. A. P. Anderson, Senior Chemical Analyst; 36. C. U. Marks, Senior Specialist, equipment analyst; 37. W. K. McCoy, Instrument Engineer; 38. L. F. Connell, Principal Equipment Dispatcher; 39. G. W. Gibson, Principal Specialist, Equipment Estimator; 40. E. M. Coslett, Assistant Equipment Specialists; 41. Abraham Rice, Clerk, Statistic; 42. Earl Petty, Director, Refining District No. 4; 43. G. W. Griffithes, Jr., Associate Refining Analyst; 44. H. J. Holdcraft, Jr., Associate Engineer; 45. Dr. Raymond Reuter, Principal Speciailst, Chemicals; 60. R. P. Wilson, Senior Analyst Specialist, equipment; 61. H. G. Gibson, Equipment Specialist; 62. Robert Deaton, Clerk.

Absent from the picture are: D. P. Bailey, Chief, Operations Section; E. B. McConnell, Technical Consultant; D. F. Flann, Principal Specialist, Cost Analyst; J. W. Griswold, Sr., Specialist, Engineer Specification; Stanley Wilk, Senior Analyst, Technical Unit; R. M. Cornforth, Senior Specialist, Technical Unit; M. J. Kiser, Principal Lubricating Oil Specialist; M. B. FitzGerald, Senior Analyst.

production of synthetic rubber under government auspices will be raised to about 900,000 long tons yearly but this rate of throughput will not be reached until 1944 when all the plants thus far provided for will be in operation. Meanwhile the stock-pile of natural rubber now on hand, plus such imports as may be had, plus the synthetic output of 300,000 tons scheduled for 1943 and the use of reclaimed rubber, will be sufficient for military needs in the intervening period.



Of particular interest to the great body of motorists because it offers them the chief hope of providing tires and tubes for their use during the next two years is the "quick" butadiene campaign that is being energetically pushed by the refining division of the Office of Petroleum Coordinator and by a special committee of the Petroleum Industry War Council. The purpose of this movement is to utilize existing facilities and available materials for the production of butadiene even in quantities too small to be considered as a permanent undertaking. In furtherance of this plan descriptions of the various methods and procedures that can be employed have been distributed to refining companies throughout the country, pilot plants have been set up and a large amount of experience is being accumulated. Wright W. Gary, director of OPC's refining division, has covered the country in trips to confer with refiners on this subject and sufficient progress has been made to indicate that by the beginning of 1943 a substantial production from this source will be under way. A survey of facilities for turning this output into finished rubber products leads OPC officials to believe that by that time there will be enough polymerization capacity to convert the butadiene into synthetic rubber.

Five methods, the OPC has explained, are being tried out in this stop-gap program. These are: air injection, tubular cracking at high temperature, injection of superheated steam, flue gas and specially designed checkerboard brick. Through the air injection method which appears to be regarded with considerable favor because of its simplicity oil is heated to as high a temperature as can be reached in an ordinary still. Air is then injected into the transmission lines so that it can "kick itself up" to even higher temperatures. Water gas plants probably will not be used as widely as at first contemplated because it has been found that the checkerboard brick would have to be respaced to get satisfactory results and because charging stocks would have to be brought to the water gas plants, which in many cases are not conveniently situated in reference to refineries. The possibilities of converting existing thermal cracking plants to the production of butadiene were fully described in a recent issue of WORLD PETROLEUM.* This calls for the use of a certain amount of critical materials though less than are required for the large permanent plants included in the government's war program previously referred to.

While these efforts look to an increased production of buna type rubber which is recognized as the most durable of the synthetics thus far developed for tire manufacture a number of other rubber substitutes or near rubbers capable of rendering service in the emergency period have entered the picture. One of these which is a product of the Standard Development Company, research organization of the Standard Oil Company (New Jersey), was dramatically demonstrated before a sub-committee of the House Mines Committee by Dr. Per K. Frolich of Standard Development at a hearing in Washington in mid-July. This product has been named Flexon, but is popularly referred to as "bath tub" rubber because of the simplicity of its processing. It is produced from isobutylene by the addition of a catalyst at a low temperature. While it is admitted that Flexon is an inferior grade of synthetic rubber it can be made into tires which will give a limited mileage under not too strenuous use. Its advantages are that it can be produced with makeshift equipment from isobutylene of which considerable quantities can be recovered from refinery gases and of which only a small proportion enters into the production of aviation gasoline. Flexon is now being made on a small scale at one Standard refinery and Mr. Farish has expressed the opinion that through extension to other refineries of the process which is open to general use a production of 100 tons daily may be reached within the next few months. Another substitute material which may aid the tire situation is Thiokol. A special committee headed by Dr. Charles F. Kettering which has been studying rubber substitutes has reported that Thiokol is suitable for use in recapping used tires and a plant for greatly expanding its production is under construction by the Dow Chemical Company, originators of the product. According to Dr. Willard Dow, president of the company, tires retreaded with Thiokol will give up to 5,000 miles of service at 40 miles per hour or less.

Light on another much-disputed question was thrown on the scrap rubber situation as the result of the special drive for the collection of scrap initiated by President Roosevelt and carried out by oil companies under the direction of the Petroleum Industry War Council. In a report to the President it was announced by William R. Boyd, chairman of the Council, that between June 15 and July 10 a total of 454,155 tons of scrap rubber had been collected and delivered to bulk plants of the oil companies. This result was regarded as gratifying in rubber trade circles where estimates as to probable collections at the beginning of the drive varied from 300,000 to 500,000 tons. The collection of used rubber is being continued as part of the general scrap gathering campaign initiated under the direction of the War Production Board and is expected to swell receipts to some extent as more old rubber is turned up in the course of this general drive.

Statements of tire manufacturers made in connection with an exhibit staged in Washington asserted that they could supply tires sufficient for 75 percent of pre-war mileage if they were allowed to receive 165,000 tons of scrap rubber and 3,000 tons of natural rubber. From the War Production Board this proposal elicited only the comment that there were too many "ifs" in it, a remark which strengthened the general impression that most of the rubber reclaimed from scrap would go to maintain the equipment of the military establishment and that little if any of it could be made available for civilian use.

Synthetic rubber made by the Standard Oil Company (N. J.): when the present program for the construction of plants to produce butadiene and synthetic rubber are completed the United States will be producing over 800,000 tons per year from domestic sources.

While the quick rubber campaign must be regarded as the chief hope of replenishment of rubber supplies for private use the movement in this direction has not proceeded far enough to make possible even an approximate estimate of its probable results. New factors are entering into the situation and new processes are being brought forward for consideration so rapidly that the picture changes almost from day to day. Among those who are acquainted with the vast amount of study and experimentation that has been required to bring the production of synthetic rubber to its present stage no miraculous solution of the supply problem is looked for but interest in the subject is so great that every proposed process that gives even a slight promise of practical results is almost certain to be tried out. Qualified experts of the oil and rubber industries express a cautious belief that through various expedients sufficient substitute materials to satisfy strictly essential transportation needs will be forthcoming. Thousands of research workers in all parts of the country are engaged in an intensive study of rubber substitutes and a steady improvement in the quality of the products already developed and in the methods of their fabrication such as have been recently announced may reasonably be looked for. Discounting hopeful possibilities and confining consideration to actual developments and the practically assured completion of plants already provided for the situation reveals a definite program which will provide an ample margin for military requirements and a less definite but substantial production to meet necessary civilian needs without impinging on the essential war

* Thermal Cracking Can Aid Nation's War Efforts—Dr. M. B. Cooke, Twelfth Annual Refinery Number, July, 1942.

program. At the present time the first government owned plants are in production and these, with the privately owned plants now in operation will provide some 32,300 tons up to the end of the year. After January 1, 1943, facilities for production will expand at an accelerated rate, and capacity for 800,000 tons yearly is expected to be in full operation by the end of 1943. Under the influence of this growing capacity, the first half of 1943 will add 73,000 tons of actual synthetic rubber to the 32,300 tons produced up to the end of 1943. During the second half of 1943 there will be produced 264,700 tons, making a total of 370,000 of actual synthetic rubber turned out by January 1, 1944. After that, with the whole producing capacity in operation as planned, the new synthetic rubber industry will be turning out about 75,000 tons a month. These figures on future production are estimates by the responsible officials concerned. They are subject to revision upward if the engineers and the contractors complete their work ahead of schedule. On the other hand, actual results may fall short of the estimates if new bottlenecks develop in critical materials, or if unexpected difficulties are encountered in operating the processes. Chief reliance for this phase of the program is placed on processes for the production of butadiene, which is to be obtained from two main sources: petroleum and alcohol. Butadiene from petroleum will contribute about 500,000 tons of synthetic rubber to the 800,000 ton yearly program. The balance will be supplied mainly by using alcohol as the starting material. This alcohol will be produced in two ways: by fermentation and distillation of grain or other agricultural products, and by hydrogenating and hydrating acetylene; the acetylene itself will be produced from coal. Though produced from such various raw materials, the butadiene resulting from these several processes will be the same chemical substance; that is butadiene from petroleum is no different in any respect from butadiene produced from grain, molasses, or coal. The main program also calls for 100,000 tons of special types of rubber, some of which require butadiene while others do not. Assertions that alcohol has been ignored are refuted by estimates which show that the program adopted will call for the use of $81,900,000 worth of grain in the production of butadiene and the raw material for styrene; $22,300,000 worth of petroleum refinery gases for the same purposes, and $9,900,000 worth of benzol derived from coal.

Aside from the above-mentioned special rubbers, all the butadiene from petroleum, alcohol and coal will be converted into the type known as Buna S. This type of synthetic rubber makes the closest approach to the natural product if manufactured with proper care; proper care in this case means that the butadiene must be carefully purified and strict attention paid to details of the rubberizing process. For military purposes the product must meet the stiffest specifications. There can here be no let-down in quality for the sake of a larger quantity.

Being fashioned to meet war demands the original synthetic rubber program considered only military necessities, with nothing left over for more than the barest civilian needs, at least not until after the 800,000 ton yearly program gets under full way two years hence. As stated above, it is expected that not more than 370,000 tons of Buna S rubber will be made up to the end of 1943 and the military establishment will take all of that. Meanwhile, the tires on the nation's 30,000,000 or more automobiles and trucks are wearing out, and many of them will certainly be gone by the middle of 1943, or at least before civilians can derive much if any benefit from the government program. Even after January 1, 1944, when the original program will be hitting its stride of about 75,000 tons a month, it probably will be some time before the accumulated demand can be satisfied.

Within the past month the seriousness of the tire shortage has come to be viewed in a clearer perspective. It is now admitted that essential civilian needs and the extent to which automobiles provide the only available means of transportation for millions of people have been underestimated.

In view of this situation the original plan to produce 800,000 tons a year of Buna S by 1944, mostly for military purposes, is being supplemented through a concerted effort to make larger provision for civilian needs. The characteristic of this addition to the rubber program is that it aims at quick results, which are to be achieved by getting "quick" butadiene and other parent substances of rubbery materials. The original program, going ahead as planned, calls for the production of butadiene in new, specially built plants which are being engineered and constructed under strict priorities and rationing of critical materials; it is the scarcity of these materials that is the real reason for inability to make greater provision for civilian needs in this program. The problem of enlarging the supply of rubber articles for general use, in particular tires, is thus reduced to the problem of building plants out of materials not classifiable as critical. It is now proposed to solve the problem of "quick" civilian rubber by improvising facilities out of any materials that may be available, such as ordinary qualities of carbon steel and junked or obsolete equipment that may be found around any refinery. These extra facilities, constructed of spare parts and junk, will produce a supply of butadiene not earmarked for the government's 800,000 ton yearly program. Such butadiene will naturally be produced under difficulties, in plants that are likely to have short operating lives, and the product will cost more than butadiene produced in regular plants that are built of critical materials; consequently the rubber produced from such butadiene will cost more. But in the current emergency, cost is a secondary consideration; it is now a case of "needs must when the devil drives." The public is going to feel a dire need of rubber before the original program comes into full operation, and owners of tire-less automobiles will readily if not cheerfully pay what it costs rather than continue to do without. Also, the petroleum industry itself, which obtains its living mostly from the sale of gasoline, lubricants and services to the motorists, is going to be pinched in the same proportion as the motorists are unable to procure new rubber. It is therefore understandable that the proposition to construct make-shift plants for producing butadiene outside of and well in advance of the government program has engaged the attention and interest of the petroleum refining industry. To further the installation of these facilities a definite campaign has been developed by the OPC, and a special committee on synthetic rubber has been appointed

(continued on page 48)

Since a minimum of two years must elapse before the synthetic rubber program will be in full operation essential civilian needs will be maintained by tires now in use plus a limited amount of reclaimed rubber.

These cubes of scrap metal, which will provide some of the millions of tons of scrap needed for defense production are baled up in this manner to prevent their burning away when they are thrown into an open hearth steel furnace.

Legal Aspects Of SCRAP COLLECTION

By Leslie Moses
Attorney, Fohs Oil Company

Question Arises as to Whether Lessee Has Right to Remove Casing and other Equipment from Dry or Abandoned Well, and Within What Time Such Removal Should Take Place.

FORMAL CAMPAIGNS are now under way in all oil-producing areas of the United States to secure for the steel mills all available scrap metals. Petroleum Coordinator Harold L. Ickes and the War Production Board have both made known the urgency of the situation. Ickes has forcibly pointed out that steel is indispensable to war efforts and that scrap is imperative in steel making. In other words, steel scrap is as vital to successful war efforts as is man power. Scrap must continue to pour into the furnaces of the steel mills in an uninterrupted stream if the mills are to keep up with the demands the war is making on the steel industry.

Of all the big industries where scrap accumulates in large quantities not as a by-product of the goods manufactured, the petroleum industry has been said to have on hand the greatest amount of scrap iron and steel. Oklahoma, Louisiana, California, Illinois, all oil producing states, are reservoirs of untapped scrap, and companies have been urged to go over all their leases with a view to spotting and collecting scrap. Abandoned and forgotten pipe lines are being rooted up, old bull wheels and cables are being hauled away from the tall grasses that have hidden them for years, rusty and corroded boilers are being gathered up. In fact, every pound of available scrap is being collected, and must be collected from the domestic and industrial sources of supply. Quite recently it was announced that the Division of Minerals of the Department of Conservation of the State of Louisiana is endeavoring to perfect a new procedure whereby abandoned oil wells may be made to yield large quantities of steel surface casing to augment the other scrap now being gathered. The question necessarily arises as to the right of a lessee to remove such casing from a dry or abandoned well. Under the general landlord and tenant relationship the right of a tenant to remove from the lease premises the fixtures he has placed thereon or therein is a matter of contract, usually an implied contract, but in a number of instances, an expressed one. Of course, where there is an express provision in the lease permitting such removal, that will control. Where there is no express provision, the law does not presume that the tenant, by placing such fixtures on the leased premises for his own enjoyment and use, and which can be removed without any damage to the leased property, were placed there for the use and benefit of his landlord after the lease had terminated. The law, therefore, raises an implied contract permitting the removal of such fixtures, provided they are removed at a proper time and in a proper manner. The right of a lessee under an oil, gas and mineral lease does not differ, in any material aspect, from the right of a tenant under the usual type commercial lease. Even in the absence of a stipulation governing the problem, personal property placed on the mineral lease by the lessee for the purpose of drilling and otherwise operating the lease in the manner contemplated therein, are trade fixtures, and may be removed by the lessee during the term of the lease or within a reasonable time after its expiration or termination. While there has been but little difficulty with respect to machinery and other equipment placed upon the surface of the lease, there has been some controversy over casing put into the well, or wells, drilled on the leased premises, and thereafter abandoned as dry and unprofitable.

Most modern leases invariably provide for the removal of casing as well as other equipment, by means of a specific clause in the lease. In a number of the instances it is substantially as follows: "Lessee shall have the right, at any time during or within a reasonable time after the expiration of this lease to remove all property and fixtures placed by said Lessee upon said land, including the right to draw and remove all casing." It is to be noted that this clause provides for the removal of the casing "within a reasonable time" after the expiration of the lease. Another clause in common usage reads as follows: "Lessee shall have the right at any time during or after the expiration of this lease to remove all property and fixtures placed by Lessee on said land, including the right to draw and remove all casing."

As was said in Standard Oil Company of Louisiana v. Barlow 141 La. 52, 74 So. 627 (1917): "It is incredible that any oil company should intend to present to a lessor $1,400 worth of pipe, after it had expended $10,000 or more in drilling a well into salt water." The court went on to say that if the lessee deferred the removal of his pipe for so long a time as to authorize a belief that he has abandoned it, a court would so hold, but that a lessee is entitled to a reasonable time to remove such pipe.

The courts, however, have steadfastly refused to construe the second clause above quoted as granting to the lessee an indefinite period of time within which he can come upon the land and remove

the casing and other equipment he may have left thereon after the lease has terminated or been abandoned. In Louisiana Oil Refining Corporation v. Halton, 64 S. W. (2nd) 98 (Arkansas, 1933), in construing a clause permitting the removal "at any time," the court said: "It seems to be the rule supported by authorities and reason that this clause should be construed so as not to give the lessee any indefinite length of time to remove his equipment after the expiration or abandonment of his lease, but that the right reserved to move the equipment must be exercised within a reasonable time and failure to do so would result in the forfeiture of the lessee's right in the property, which would thereafter be considered as a part of the realty and title thereto vested in the Lessor." Such language, of course, is very true, and presents a fair view of the situation. However, to determine what constitutes a "reasonable time" is not as easy as saying that the casing can be removed within a "reasonable time" after the abandonment of the well or the lease. Is it a question of law, one that can be settled by the establishment of a hard and fast rule by the courts, or is it a question of fact, each case being dependent upon the circumstances surrounding it?

As far back as 1900 a Colorado case, Updegraff v. Lesam, 62 Pac. 342, refused to set a definite rule to follow, saying: "A reasonable time within which a lessee may remove personal property placed on the premises after the expiration of his lease is not a fixed period. What would be a reasonable time in one case would not be a reasonable time in another, and, therefore, in every case the question, what is a reasonable time, must be determined from the facts and circumstances peculiar to that case."

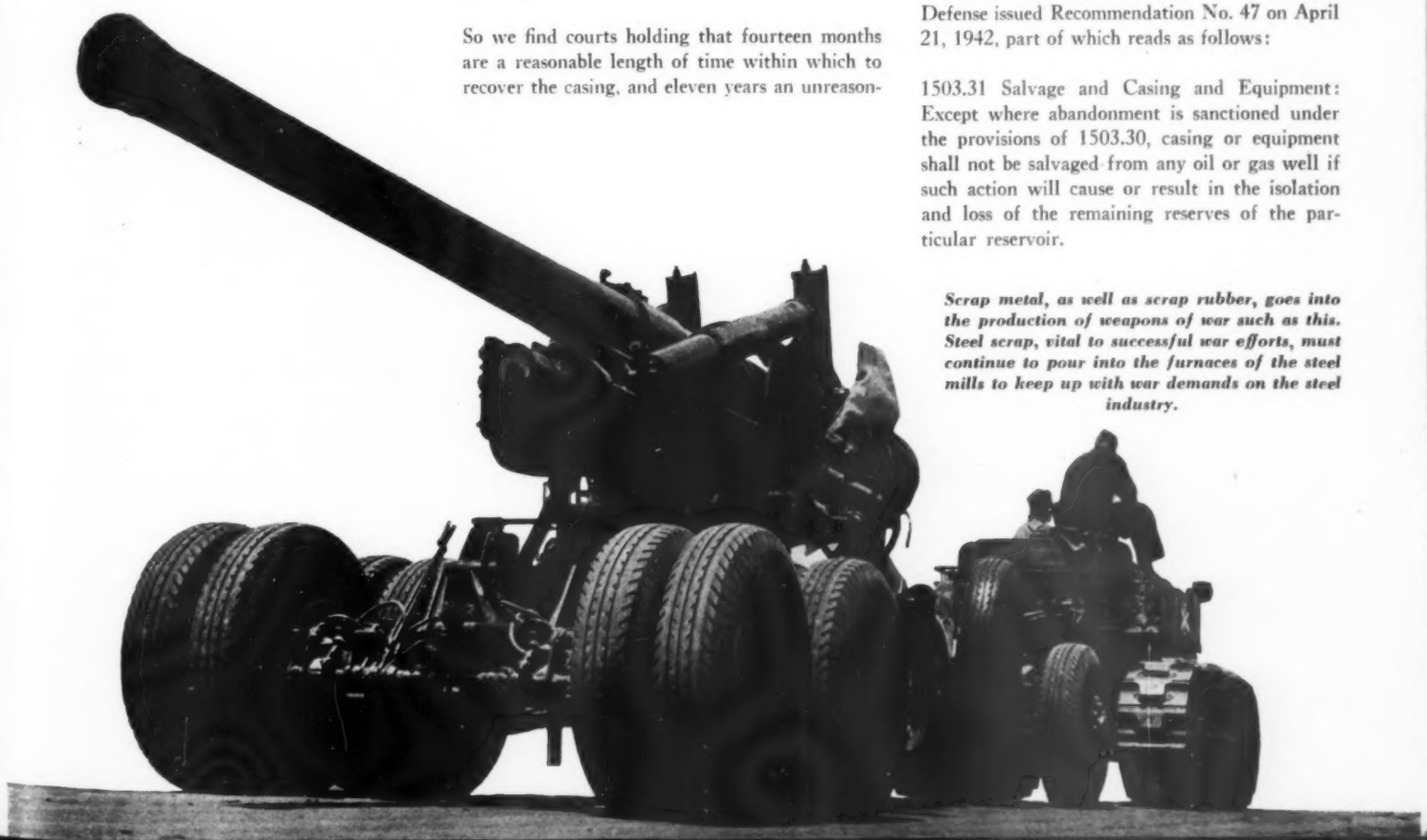
In 1929 a Texas court, in Armstrong v. Federal Supply Co. 17 S. W. (2nd), added its bit thusly: "What constitutes reasonable time is a mixed question of law and fact. ***The authorities on what constitutes a reasonable time in such cases are not numerous." In Meers v. Frick-Reed Supply Corp. 127 S. W. (2nd) 493 (1939) the Texas courts enlarged upon their previous statement by adding: "That which constitutes a reasonable time is a question of fact, or, at least, a mixed question of law and fact, and depends upon the circumstances surrounding the case to which the principle is sought to be applied. What would be a reasonable time in one case might be wholly inadequate to shut off the rights of the parties in a different case or under different circumstances." There must, however, be some yardstick by which to measure your rights. In the Meers case the court went on to say: "The general conception of that which constitutes a reasonable time under the law is such length of time as may fairly be necessary, considering the nature of the duty to be performed and the circumstances surrounding the matter in hand. It is that time which upholds and saves to each of the interested parties the rights to which they are entitled and protects them from injury or loss." Probably the most complete statement of what constitutes reasonable time is found in Lewis v. Clark, 149 S. W. (2nd) 244, where Texas again considered the problem, in 1941, and defined a reasonable time as: "such length of time as may fairly and properly and reasonably be allowed or required, having regard to the nature of the act or duty and to the attending circumstances; that time which, as rational men, the parties to a contract ought to have understood each other to have in mind; that time which preserves to each party the rights and advantages he possesses, and protects each party from losses he ought not to suffer."

So we find courts holding that fourteen months are a reasonable length of time within which to recover the casing, and eleven years an unreasonable time; eight months very reasonable, and four years unreasonable. Where the dividing line exists, no one knows, and until the reasonable time is stretched to where the courts have begun to define what constitutes unreasonable time, no one will know. Two years are probably reasonable, over three years, probably unreasonable, but that is merely one man's opinion, and most appellate courts are composed of from three to seven men. However, contingencies will arise that will excuse the lessee from removing the casing or other fixtures immediately upon expiration of the lease, or within a reasonable time thereafter. Where there are disputes between lessor and lessee as to when the lease expired, or whether or not it had expired, lessee has a "reasonable time" after the ultimate judicial decision in the case within which to remove his casing and other equipment.

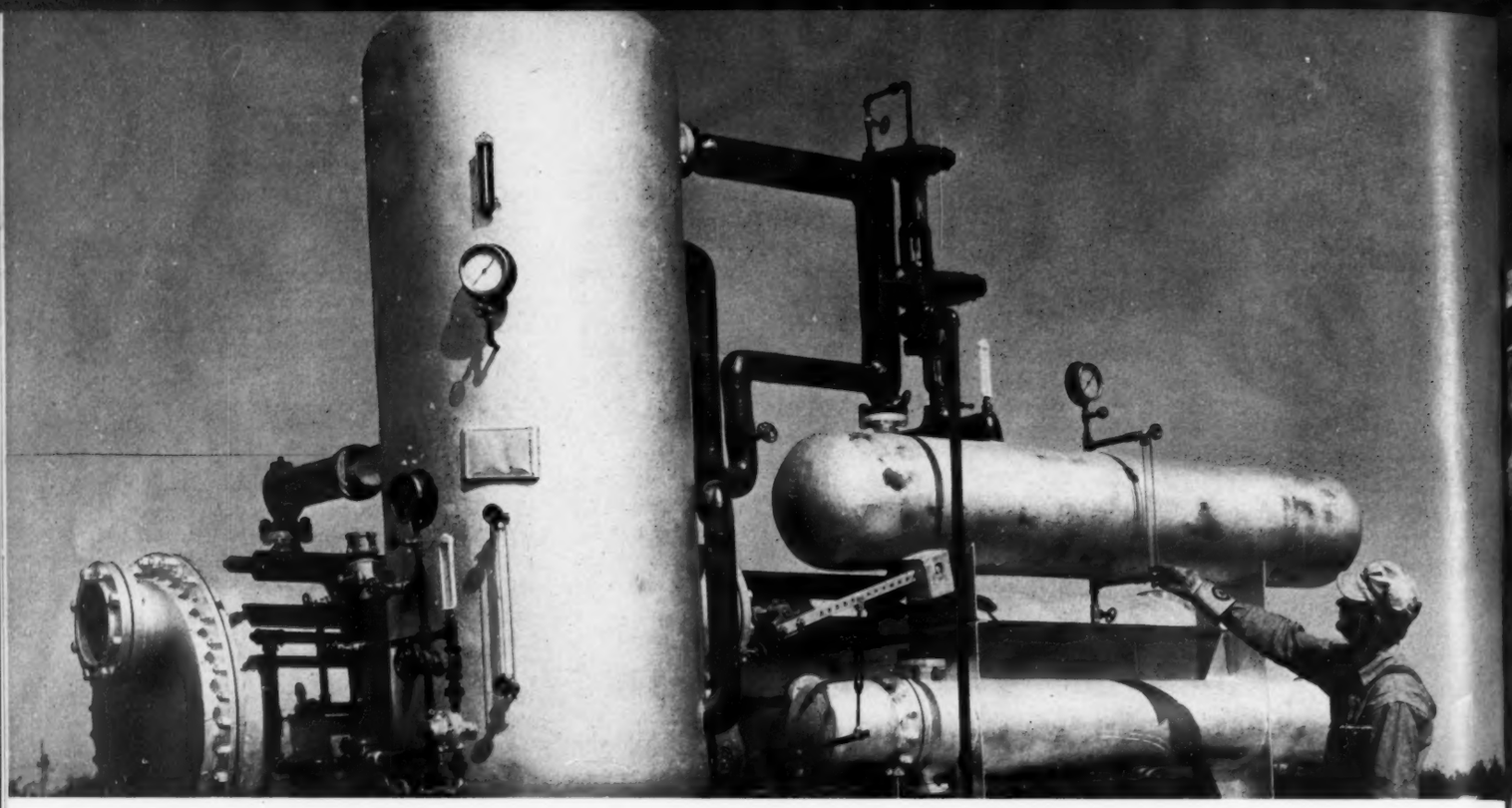
One other thing of importance, where a lessee has abandoned a well or a lease whereon there is a well, and such well is still producing, some courts are inclined to hold that the removal of the casing will injure the well and the lessee has no right of removal. On the other hand, other courts have held that even though such removal will destroy the well, the lessee has the right so to remove. It must be borne in mind, however, that in the desire to augment scrap tonnage sent the mills, caution should be exercised so as not to scrap useful material. In appraising casing and other equipment before consigning them to the scrap heap, one must take into consideration possible utilization under less strenuous usage. In other words, scrap is imperative, but scrap obtained at a cost of wrecking equipment with hours of service still in it is obtained at a price far beyond its economic or military value.

Since the foregoing article was written Harold L. Ickes, Petroleum Coordinator for National Defense issued Recommendation No. 47 on April 21, 1942, part of which reads as follows:

1503.31 Salvage and Casing and Equipment: Except where abandonment is sanctioned under the provisions of 1503.30, casing or equipment shall not be salvaged from any oil or gas well if such action will cause or result in the isolation and loss of the remaining reserves of the particular reservoir.



Scrap metal, as well as scrap rubber, goes into the production of weapons of war such as this. Steel scrap, vital to successful war efforts, must continue to pour into the furnaces of the steel mills to keep up with war demands on the steel industry.



Fuel Vaporizer ready for installation at the booster station of the Continental Pipe Line Company. This apparatus extracts enough gas from the crude being pumped to operate the two 115-hp. Buda engines doing the pumping.

FUEL VAPORIZER

Provides Cheap Power For Pipe Line Operation

Apparatus Devised by Continental Engineers Transforms Crude Oil to Economical Engine Fuel—Permits Use of Gas Engines Where No Gas is Available

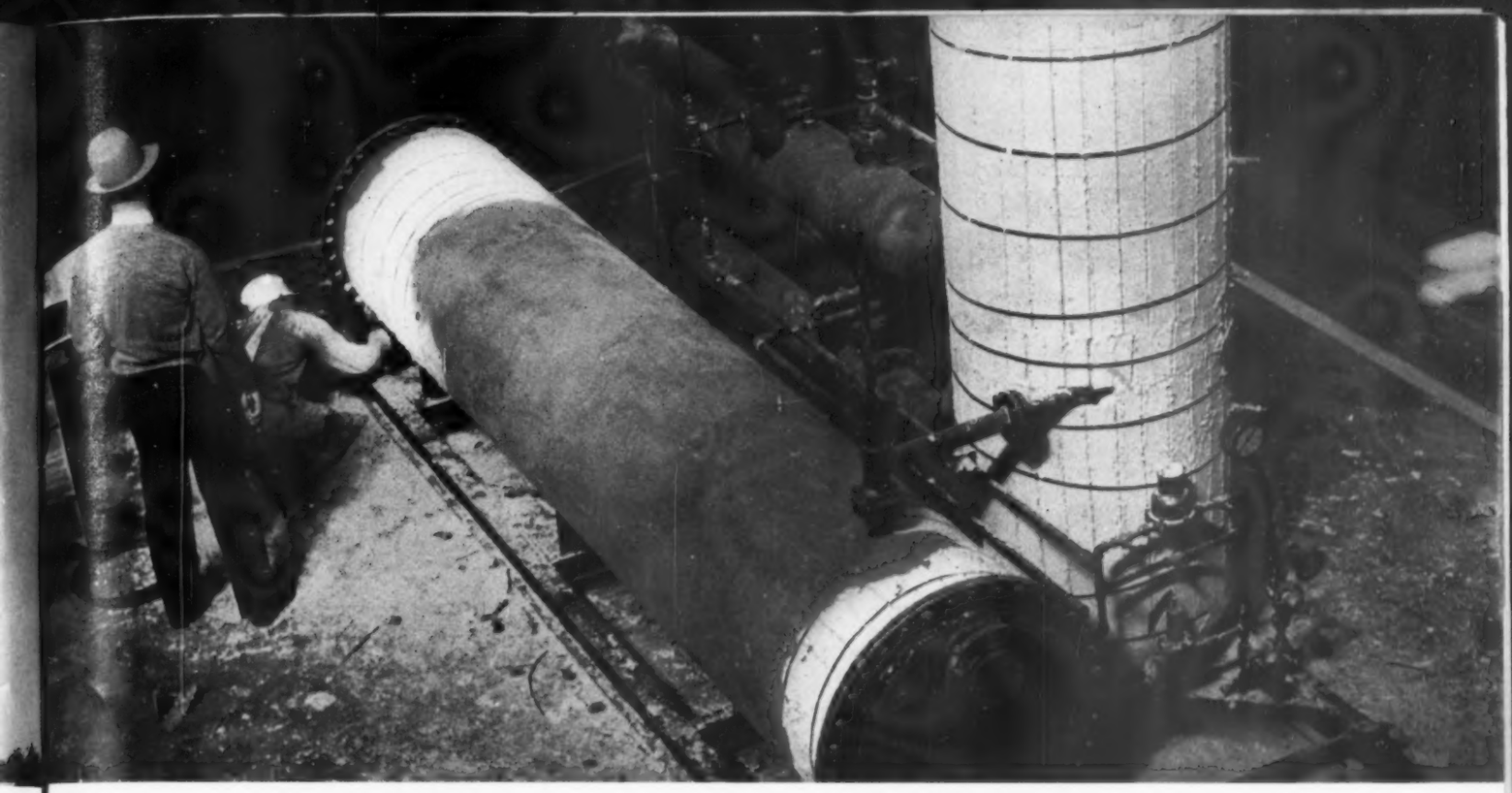
A FUEL VAPORIZER that will extract from the crude oil being pumped enough gas to operate the engines doing the pumping was recently patented by two Continental Oil Company executives, J. G. Dyer, vice-president in charge of production, and A. C. Wilkinson, general pipe line and terminals superintendent. The rights to the vaporizer have been assigned to Continental.

The new vaporizer has several advantages of major importance today when the use of existing equipment and the avoidance of transportation of special fuels are absolutely vital. First, it makes possible the use of gas engines instead of difficult-to-obtain and more expensive Diesels, even where no gas is available. Second, it eliminates transportation of special fuels. Third, it provides cheaper power and cheaper fuel. Fourth, it can be set up and operated without any outside housing, or can be tucked away in a small space in existing housing. Fifth, it is easily transported to the next point of use when changes in location are necessary. The first of these fuel vaporizers was installed early in 1939 at the Douglas, Wyoming, booster station of Continental Pipe Line Company, when it was found very difficult to obtain suitable fuel for the operation of the gas engine during the winter months. At Douglas the vaporizer operates a 115-hp. Buda gas engine. Later installations have been made at Guernsey, Wyoming, where the apparatus provides fuel for two 115-hp. Buda gas engines, and at Fenton, Louisiana, where it fuels a 350-hp. two-cycle Cooper-Bessemer gas engine.

Operation of the fuel vaporizer is simple and requires little attention from an operator. From the discharge side of the booster station, crude is tapped and sent through a pressure regulator valve, where the pressure is reduced. The crude is then routed into a heat exchanger, where the temperature is increased about 120° F. and then passed to an exhaust gas heat exchanger, where the temperature is upped to approximately 300° F. Transferred to a flash separator at this temperature, gas is extracted from the top of the separator and sent directly to the engine carburetor to operate the gas engine. Baffle-plates in the top of the flash separator collect condensed gasoline, which drops out of the separator and is drawn off into the gasoline volume tank. This stock is held in reserve to start and run gas engines which operate on gasoline, providing the necessary fuel to run the engine for about an hour, when sufficient heat has been built up to operate the fuel vaporizer. For engines which are not equipped with carburetors and which will not run on gasoline, a fuel oil burner is installed in the flue gas burner to supply heat for vaporizing the gases for starting the engine. Bottom oil from the flash separator flows through an automatic float dump valve around the coils of the heat exchanger, where the fresh crude is heated as it enters, and at the same time the bottoms are cooled as they return. Cooled, the bottoms are then sent to the suction side of the pump and back into the crude line. When pressures on the suction side of the booster station exceed the operating pressures of the unit, it is necessary to dump bottoms into a sump and pump them back into the line through a sump pump. When the gas volume tank is partially filled with gasoline, manipulation of a couple of valves holds the liquid level and the balance of the gasoline re-

ANALYSIS OF GASOLINE PRODUCED BY FUEL VAPORIZER AT GUERNSEY, WYOMING

		B.T.U. per Cu. Ft.	B.T.U.'s
Propane	3.88%	2,580	100
Butane	5.88%	3,350	197
Pentane	13.75%	4,007	551
Hexane	22.76%	4,730	1,077
Heptane and heavier	53.73%	5,540	2,977
Total B.T.U. content per cu. ft.			4,902



Among the important advantages of the fuel vaporizer is the ease with which it can be transported to the next point of use, being mounted on skids; and its complete insulation which dispenses with the necessity of any outside housing.

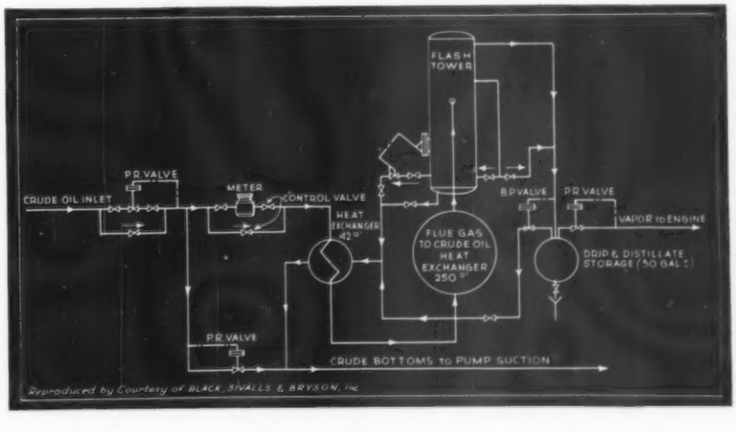
turns to the flash separator and is dumped into the bottoms. Sufficient gasoline has been accumulated in the volume tank on one installation to operate two small gasoline engines which are used for pumping water and for generating electricity. Although the crude undergoes some loss of gravity as it passes through the vaporizer, the small amount of oil necessary to operate the unit makes it impossible to note the loss when the crude is received at the end of the line. At the Guernsey installation, where 13,000 barrels were pumped daily through the crude line, only 35 barrels were withdrawn to operate the fuel vaporizer, and 30 barrels were returned to the line. As a matter of fact, the ends taken off in the flash separator are so light, they would undoubtedly be lost in transit anyway, so the very small reduction in crude quantity constitutes the only operating cost of the unit.

The fuel vaporizer is manufactured by Black, Sivalls and Bryson, Inc., Oklahoma City, Oklahoma, in a single unit, insulated, and mounted on steel skids. It can be loaded on a truck and hauled anywhere, and does not need any protection from the weather, not even in Wyoming, where the first of the units was tried out. It can be installed in three hours—all that is necessary is to make three connections: (1) to the exhaust of the engine, to secure the heat for vaporizing; (2) to a one-inch line from the discharge side of the pump, to secure the crude; and (3) to a two-inch line from the flash separator back to the suction side of the pump, to return the bottoms to the line. The units in operation are tested for 125 pounds pressure, and can make gas for engines up to 350 hp. They have been used on both two-cycle and four-cycle gas engines, and are so compactly fitted together, the 350 hp. size measures only six feet wide, eight feet high, and 16 feet long.

The products being burned as gas were found to be very high in B.T.U., and Continental contemplated some difficulty with burned-up valves, particularly exhaust valves, because of the extremely high heat developed. They found, however, that no trouble was encountered from this source, and no replacements of exhaust valves have been necessary at any of the installations. In fact, all three units have served since installation without any repairs whatsoever. It is completely unnecessary to doctor up the gases produced by the fuel vaporizer in any way, or even to mix them with air, before sending them directly to the carburetors of the engines through an ordinary gas regulator. The fuel vaporizer has been tested on various gravities of crude, on crude that has been stabilized, and on casinghead gasoline, and it has proved satisfactory on all counts.

TEMPERATURES AND PRESSURES FUEL VAPORIZER AT GUERNSEY, WYOMING

Exhaust gas to heater	1,000° F.
Exhaust gas to air	300° F.
Oil to bottom exchange	56° F.
Oil out bottom exchange	120° F.
Oil out of heater to flash separator	260° F.
Top temperature flash separator	260° F.
Temperature condensate recovered	180° F.
Hot oil to bottom exchange	260° F.
Incoming pressure	25 lb.
Pump discharge pressure	733 lb.
Engine r.p.m.	950
Flow rates-meter	66.40 bbl.



Flow chart showing the arrangement of the fuel vaporizer which will produce gas from pipeline crude oil to drive the booster station pump engines.

Electrical Features of

PLANTATION PIPE LINE

By M. A. Hyde* and H. B. Britton**

System Adopted for World's Largest All-Electric Powered Line Combines Flexibility of Operation with High Degree of Automatic Control.

PLANTATION Pipe Line Company's new 1254 mile pipe line system from Baton Rouge, La., to Greensboro, N. C., is the largest ever built for the handling of refined petroleum products and is the largest all-electric-powered pipe line in existence. First full-length delivery was made early in February 1942, and immediately the line became an important factor in the transportation of gasoline and fuel oils to a large area in the southeastern states. Compared to the usual pipe line, this system operates under highly exacting conditions, and in its design the electrical and associated control features are of prime importance. The major electrification problems were: (1) To design for economical future increase in line capacity; (2) To provide flexibility in operation to meet varied schedule requirements; (3) To coordinate pumps, motors, and control so as to accomplish the starting of units reliably and with reasonable demand on the station power service; (4) To design stations for safe handling of petroleum products; (5) To develop a station control system, coordinating the electric and hydraulic control devices and meeting the requirements of single-attendant operation.

The statements made in this report regarding the capacities, pressures, and horsepowers, both for present operation and future installation possibilities, do not necessarily represent actual conditions, but do indicate the general principles involved. The system comprises an unloading dock at Baton Rouge, La., with a short line of four parallel 12-inch pipes to a storage tank farm and the initial station of the pipe line proper, a section of 12-inch line, followed by a section of 10-inch line, terminating at Greensboro, N. C. Four branch lines serve areas to the north and south of the main line. The tankage at Baton Rouge, La., main line station is used to store incoming shipments, and to make up pipe line shipments (known as tenders) according to the system schedule. Smaller storage facilities are located at the branch line origins. Approximately 30 delivery terminals are situated at various points along the system, each with facilities for handling several products. The handling of multiple products to 30 delivery points creates a scheduling and dispatching problem probably far more complex than on any existing line.

The capacity of the line as initially equipped is 60,000 barrels per day of gasoline through the 12-inch section and 42,000 barrels per day through the 10-inch section. This requires two 600 hp. motor driven main-line pumps for each of the seven stations on the 12-inch line, and two 450 hp. units on each of the seven stations on the 10-inch line. Each of three branch lines is served by a single 150 hp. unit. A 450 hp. unit is required at the origin of the fourth branch line, plus an additional booster station requiring a single 450 hp. unit. The unloading station at Baton Rouge dock contains five 600 hp. units, providing ample capacity for rapidly unloading two tankers simultaneously. The initial main-line station at Baton Rouge tank farm contains a complete spare pump unit to insure the availability of two units at all times. The system comprises 16 stations with a total of 39 centrifugal pumping units exclusive of tankage pumps and auxiliary pumps.

The present installation is designed as a long-term project to cover the commercial needs of the territory served and to operate economically on that basis. At the same time provision is made for possible future operation at increased capacity. The maximum pressure at which the line will be operated is approximately 900 psi in the 12-inch section and 975 psi in the remaining section. These values are determined by the allowable unit stress in the pipe walls which in turn is a matter of economics in the design of the line. It is necessary in centrifugal pump operation that

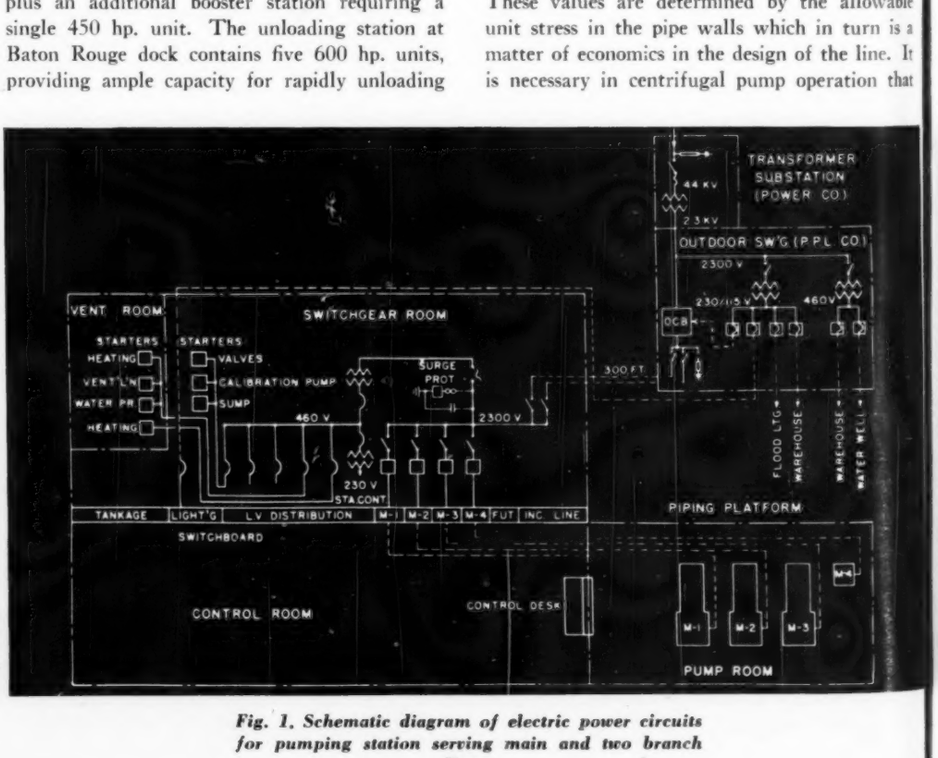


Fig. 1. Schematic diagram of electric power circuits for pumping station serving main and two branch lines.

Presented before A.I.E.E. June 1942.
*Westinghouse Electric & Mfg. Co.
**Chief Engineer, Plantation Pipe Line Co.

positive suction pressure be maintained at each pump, and if the minimum allowable suction pressure at the initial pump is established as, say, 40 psi, then with a maximum allowable station discharge pressure of 900 psi, the pressure increment introduced into the line at any station is 860 psi, plus the pressure loss through the station piping. The stations are so spaced, then, that the pressure drop between stations due to fluid friction at rated line throughput, plus the static pressure differential totals approximately 860 psi. Between the discharge of one station and the suction of the next, with uniform pipe, there is a uniform decrease in the component of total pressure due to line friction, this pressure drop being directly proportional to the distance from the upstream station. Referring to Figure 3, which represents a level section of 12-inch line, SA represents the suction pressure at initial station A, DA the discharge pressure at this station, and line DA-SB the pressure gradient along some 60 miles of line from Station A to Station B, for a flow rate of 60,000 barrels of gasoline per day. This is the flow that can be carried by the line under the conditions prescribed. If Station B is at an elevation higher than Station A, the distance between stations must be decreased by an amount that will reduce the friction drop sufficiently to provide the pressure differential necessary to balance the positive static head, and if Station B is lower than Station A, the distance between them will be increased to compensate for the negative static head.

To increase the capacity of the line without exceeding the maximum allowable working pressure, a second series of intermediate pressure increments may be added, one of which is represented by intermediate station M. If this station is placed between Stations A and B, the same pressure increment may be introduced at Station M as at Station A. The flow rate then will increase to a value such that the pressure drop between Station M and B will be the same as existed between Station A and B before adding pressure increment at M. For the line in question this flow rate for gasoline is calculated at approximately 90,000 barrels per day. When this higher flow rate is established, obviously the horsepower input per station must be increased in both the initial and added stations. Whereas the initial stations are equipped with two 600 hp. units for 60,000 barrels per day throughput, operation at 90,000 barrels per day will require two 900 hp. units in all stations. All stations on the main line are arranged for future changeover to higher capacity by initially installing pumps of such design that new impellers can be readily substituted, and motors designed for ultimate operation at the increased horsepower. These motors are of the total enclosed fan-cooled type, and in order to secure efficient operation of the 12-inch line motors at 600 hp., they are equipped initially with a ventilating fan designed to deliver only the amount of ventilating air required by the motor operating at this capacity: when the changeover to 900 hp. is made, no electrical or mechanical changes are involved except replacement of this one fan on the front shaft extension. Similarly, on the 10-inch section of the line, motors of ultimate 600 hp. capacity are installed with initial fan capacity for operation at 450 hp. The motor control and power supply equipment in all the main-line booster stations are designed for operation at the ultimate ratings.

All motors 75 hp. and above are 2300 volt. All motors above 150 hp. are 3600 r.p.m. All motors 450 hp. and above are mechanically interchangeable, simplifying the problem of spare equipment, because a spare motor of 600/900 hp. design can be installed on any line pump unit in the system except the 150 hp. branch line units. This feature also provides maximum utility of the equipment under unpredictable future alterations due to changed operating conditions. While the line is designed for a certain rated capacity, consideration must be given also to its flexible and economical operation at reduced throughputs. Contrary to practice on lines handling one uniform type of tender, the throughput of this line must be held above a certain minimum rate, to prevent excessive contamination between adjoining tenders passing through the line. Between this rate and the full capacity of the line it is desirable from the standpoint of power consumption, to operate at a rate as low as will suffice to meet the transportation schedules.

Motors of the constant speed type are preferred because of their simplicity, and their adaptability to construction suitable for hazardous atmospheres. Installation of two units per station, operated at constant speed, with the pumps connected in series, provides the required degree of flexibility. With this arrangement, and with all stations along the line having piping installed to permit by-passing any unused unit or station, changes in throughput in steps of a few percent can be made by operating 2, 1 or 0 units in properly selected stations.

With the station locations determined solely by the hydraulics of the line, and therefore, without regard to existing power facilities, it was

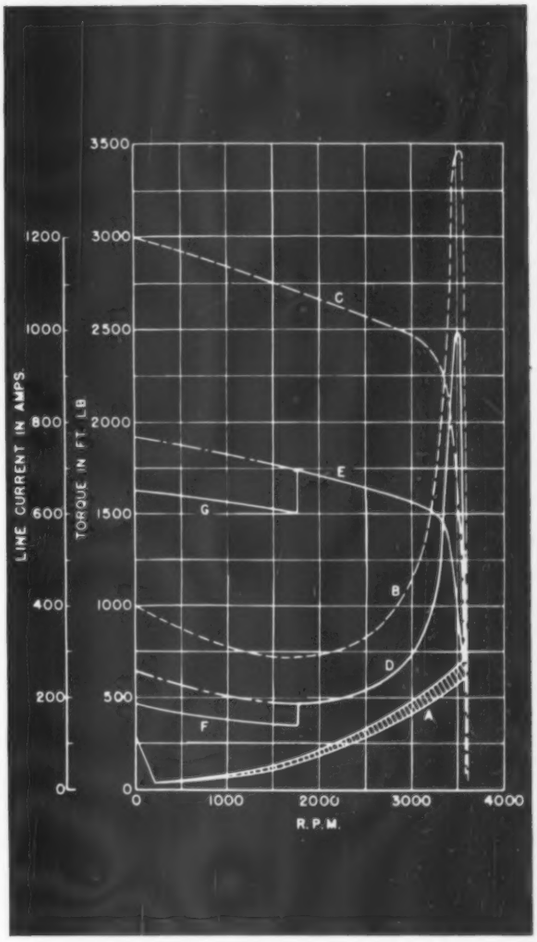


Fig. 2 above: Starting characteristics of motor-driven pump on 12-inch line.

A—Speed-torque for pump starting with closed discharge.

B—Speed-torque for motor starting on 100 percent voltage.

C—Speed-line current for motor starting on 100 percent voltage.

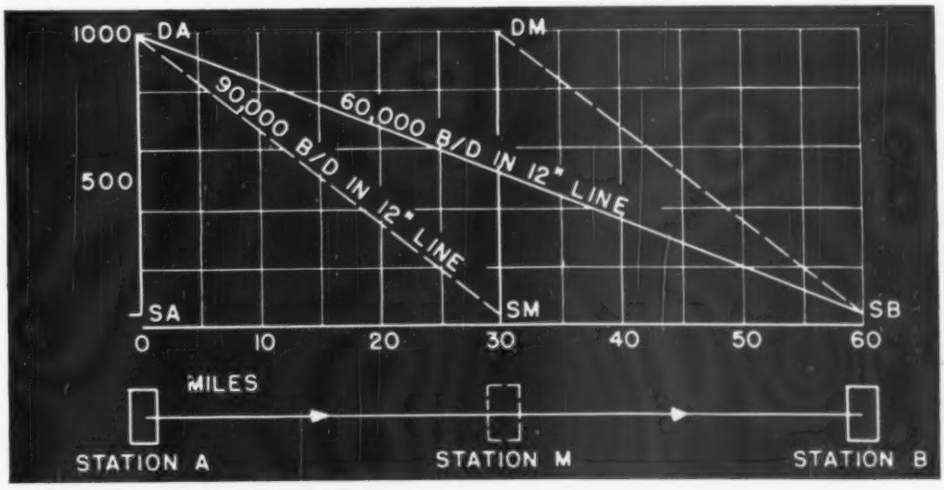
D—Speed-torque for motor starting on 80 percent voltage auto transformer tap.

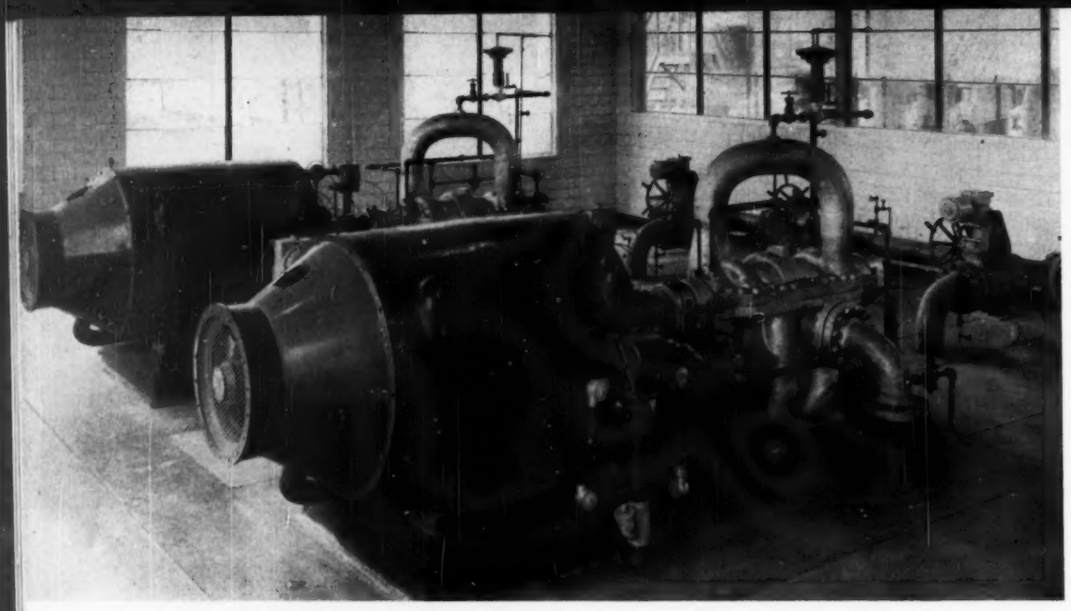
E—Speed-line current for motor starting on 80 percent voltage auto transformer tap.

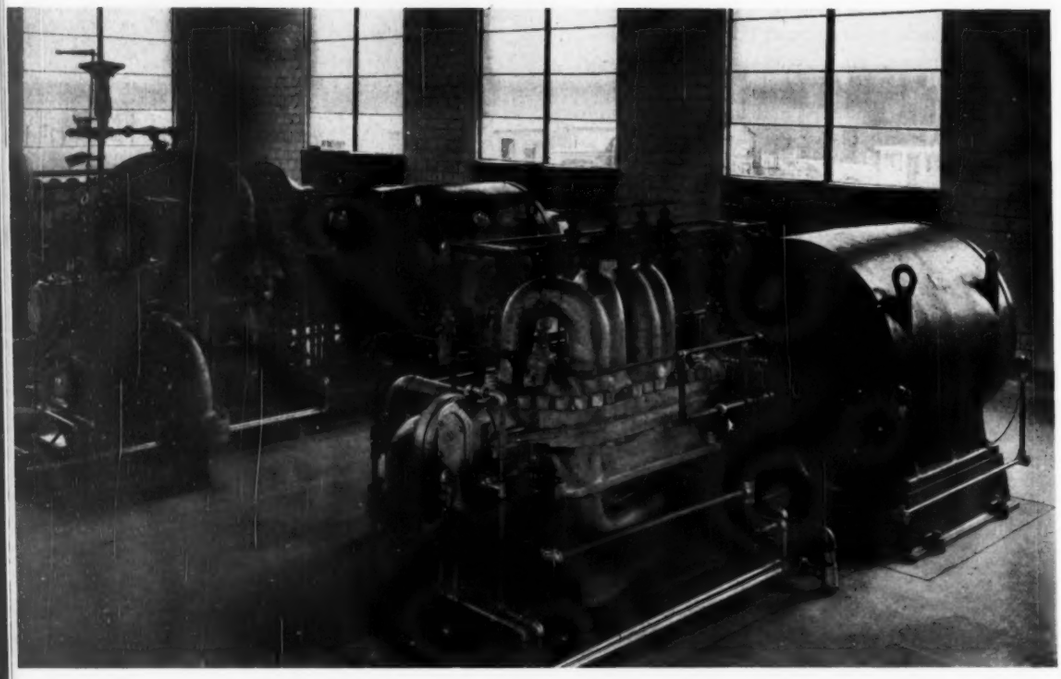
F—Speed-torque for motor starting on 80 percent voltage auto transformer tap with series reactor.

G—Speed-line current for motor starting on 80 percent voltage auto transformer tap with series reactor.

Fig. 3 below: Pipe line pressure gradients for flows of 60,000 barrels per day and 90,000 barrels per day.







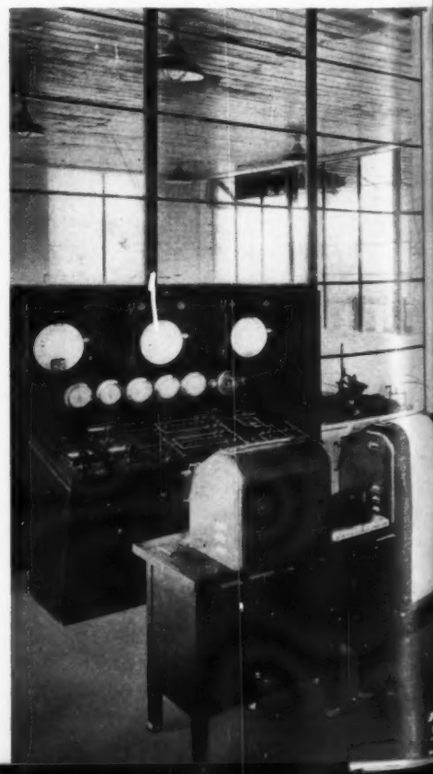
necessary to consider carefully the method of starting the units, from the standpoint of voltage conditions on the electric service. Most stations contain two main pumps comprising 95 percent of the station load. From the standpoint of starting conditions the 12-inch line motors are 900 hp., and the 10-inch line motors 600 hp. The motors are of low starting torque design in order to minimize rotor resistance and attain high operating efficiency, important in view of the high load factor at which the system will operate. To minimize current peaks during starting, motor starters for all units 450 hp. and above are of the auto-transformer type, with closed-circuit transition. During the brief interval when the motor is transferred to full voltage with its terminals still connected to the starting tap, a reactor is inserted between the auto-transformer tap and the motor to limit the current in the auto transformer circuit. By suitable control this reactor also provides an additional reduced voltage starting step when power is first applied to the motor. During starting, the discharge valve of the centrifugal pump is closed which minimizes the required motor torque. After the unit is up to speed the discharge valve is opened slowly so that the change in the direction of flow through the station piping will be gradual, for well-known hydraulic reasons. Speed-torque curves for the pump with closed discharge, and for the motor with various applied voltages, are shown in Fig. 2. These curves apply to the 12-inch line pumps when equipped with impellers for 900 hp operation, representing the most difficult conditions that must be met. The speed-torque requirements of the pumps are shown as a band curve, the upper limit applying to the pump when operating on fuel oil of specific gravity .83 and the lower limit for gasoline of .73 specific gravity. Motor speed-torque curves and line current torque curves are shown for full voltage, also for 80 percent voltage applied by auto-transformer. Also shown are speed-current curves for 3-ste

Top: Pump room of typical main-line station on Plantation Pipe Line System.

Center: General view of pump room showing two main line pumps (left) and branch-line pump (right) driven by 450/600 hp. explosion-resisting motors.

Right: Control desk, gauge board, teletype and telephone facilities, and panels for incoming line, motor starters and low-voltage power distribution, in a typical two-unit station.

Opposite Page: Control desk set into vapor-tight wire-glassed partition, through which the pump room is clearly visible.



starting with the reactor initially connected between the auto-transformer tap and the motor. With the reactor in circuit approximately 85 percent of the tap voltage appears at the motor terminals during the first portion of the initial starting step.

During starting, the voltage actually applied to the motor terminals should be of sufficient value to enable the motor to develop the torque necessary to accelerate the unit reliably to a speed above pull-out on the starting tap; when this speed is exceeded the current decreases rapidly and transfer to full voltage can be made on a low-current portion of the motor current-torque curve. Acceleration occurs directly as the excess of motor torque beyond pump input torque and inversely as the total inertia of the unit. Starting must be accomplished within a reasonable time, a limit of the order of 30 seconds being established as desirable by considerations of heating of the fluid within the pump casing. To perform the accelerating duty within this time limit it is found that the speed-torque curve of the motor when operating from the auto-transformer tap should not fall below the curve corresponding to an applied voltage of about 1630 volts. This means, when accelerating with the motor on tap giving a voltage of 80 percent of line voltage, and with the reactor shunted, the voltage supply to high-voltage side of the starting auto-transformer must be not less than: 1630 volts ÷ .80 = 2038 volts, or 88.6 percent of normal 2300 volts. Using a starting tap giving 85 percent of line voltage, the voltage supply to the starting equipment must be not less than: 1630 volts ÷ .85 = 1918 volts or 83.4 percent of normal 2300 volts.

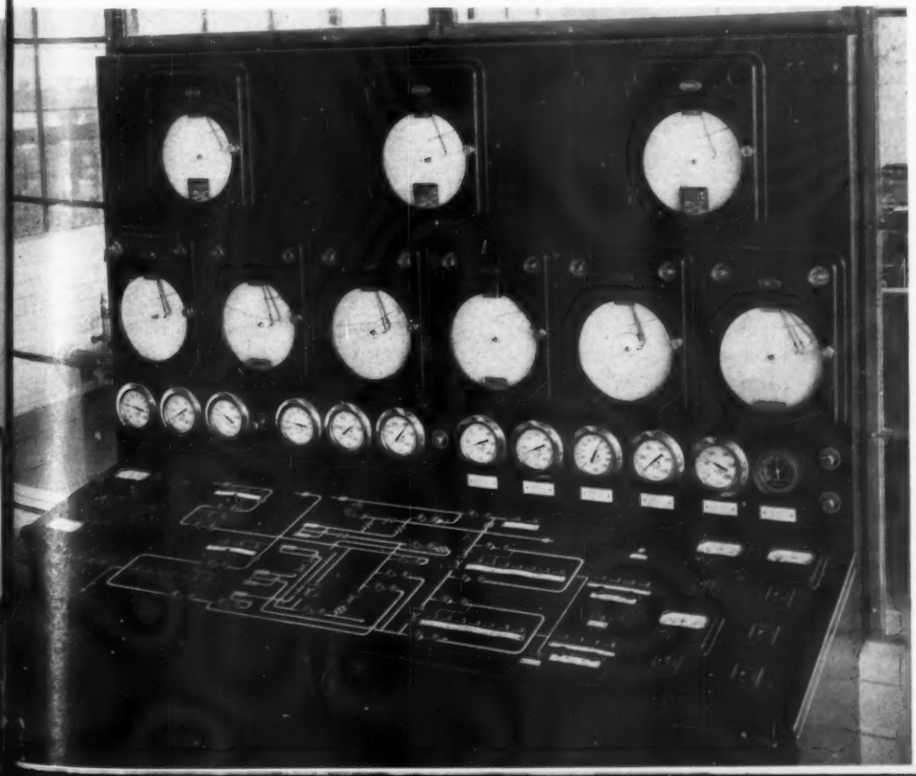
To accommodate both present and future pump requirements, as well as variations in voltage conditions encountered at the several stations, the starters for the 600/900 hp. motors were equipped with auto-transformers having taps to deliver, under starting load, 80, 85, or 90 percent of line voltage. In the first portion of the initial starting step, when the reactor is inserted into the tap circuit, the voltage at the motor terminals for these three tap connections is respectively, about 68, 72 or 76 percent of normal line voltage.

Safety problems introduced by the handling of petroleum hydrocarbon products of volatile and inflammable nature required special construction throughout the design of the stations. The areas subject to the occurrence of hazardous atmospheres (class I Group D as defined in the National Electrical Code) are the pump room and adjoining piping platform. The pump room contains the pumps with associated valves, hydraulic control devices and piping. On the piping platforms are situated the incoming and outgoing line piping and all necessary station and auxiliary piping with associated scraper traps, strainers, filters, valves, a sump tank with motor-driven pump for its service, and in many stations pressure reducing valves and fluid meter and meter calibration facilities for delivery of product from the line to the distribution terminals.

The pump room is ventilated by a flow of incoming fresh air through glass-wool filters below the windows in the front wall of the station and directly opposite the motor air intakes. This air is forced through the motors by the motor blowers and discharged toward the rear wall of the pump room. In the rear wall, just below the ceiling, are mounted one or more motor driven exhaust fans which discharge the air from the pump room and onto the piping platform. The piping platform is open on three sides with a flat roof for weather shelter, a construction affording maximum natural ventilation. The piping platform and pump room are at ground level, and in their design trenches and other depressions favorable to accumulating hydrocarbon vapors were avoided. All electric motors, control, signal devices, motor operated valves, lighting fixtures, and wiring installation in this area are specifically designed for service in Class I Group D hazardous atmospheres.

The 600/900 hp. motors on the 12-inch line pumps are believed to be the largest, explosion-resisting motors ever built. Attainment of this rating in a relatively compact construction—an important consideration in explosion-resisting design—is accomplished by the circulation of large volumes of cooling air through the motor frame and by the use of Class B insulation with the motor rating based on 75° C. rise. All main-line pump motors have sleeve bearings, oil ring lubricated and cooled by air blast from the motor ventilating fan. These bearings require no oil circulating system, consequently each motor is an entirely self-contained unit without external accessories. Control apparatus is of dead-front construction. With appropriate measures taken for safety, experience in products pipe line operation indicates that provision of a non-hazardous location, and installation therein of switchgear and control apparatus of open design, is preferable to the use of special forms of switchgear and control in explosion-resisting or oil-immersed enclosures designed for Class I Group D location. This is true from both cost and operating standpoints. The importance of accessibility hardly can be overemphasized; since the several stations on a pipe line operate in series and interdependently, it is imperative that during the operation of the line any inspection and maintenance work on electrical equipment be performed without shutdown, or in emergency with the very minimum of shutdown time.

Non-hazardous conditions are maintained in all parts of the pumping station building, except the pump room and piping platform. The non-hazardous portion of the building, designated as the operating section, has a floor level about three feet higher than the pump room floor, and is completely separated by wall from the pump room and piping platform. No direct connection is provided between these areas, it being necessary to pass through outside entrances in going from one to the other. The atmosphere in the operating section is maintained in safe condition by outside air drawn into the building at the end opposite the pump room, maintained at a pressure a few inches above the outside air and above the atmosphere in the pump room. This insures that any air seepage through the wall separating the operation section from the pump room or piping platform will be in the direction to prevent entrance of hazardous atmosphere to the operating section. The operating section of the station comprises a control room, switchgear room, ventilating and auxiliary room, lavatory, and in three of the stations a division superintendent's office. The wall between the control room and the pump room consists of a vapor-tight, wire-glassed observation window. Into the center section of



this window is sealed a vapor-tight steel gauge board, on which are mounted hydraulic recording and control devices and indicating pressure gauges as will be discussed later. These devices are gasketed to prevent passage of vapor through the mounting openings. To provide for safely shutting down the station in case the control room should become hazardous due to an equipment failure, an explosion-resisting "emergency" pushbutton is mounted on the control desk contiguous to the gauge board. By pushing this button, the attendant will trip the circuit breaker at the origin of the incoming power feeder. This breaker, normally controlled from the incoming line panel in the station, is located at the transformer substation approximately 300 feet from the pumping station. From the outdoor breaker, an underground circuit runs to a 2300 volt bus in a switchgear room, which in turn feeds the main pump starters as well as a 2300/460 volt transformer bank serving all the station auxiliaries. Energy for the control circuits of the motor starters and for signal lights and alarms is furnished at 230 volts through a transformer from the station auxiliary supply. A single-phase transformer connected to the 2300-volt service ahead of the station power breaker supplies station lighting and outdoor lighting at 115/230 volts through separate low-voltage outdoor breakers. At some of the stations there are loads outside the station proper, such as fire pumps, water well pumps, and warehouse, which must be operable even when the pumping station is shut down. To carry these loads, as well as the lighting load, a 2300 volt bus is provided on the outdoor structure, connected to the power service ahead of the station power breaker. To this outdoor 2300 volt bus are connected the station bus breaker, the lighting transformer, a 2300/460 volt transformer bank for outside auxiliaries and a 2300 volt fire pump circuit. With this arrangement of circuits, shown schematically in Figure 1, the station operator can clear all power circuits within the station proper by opening the 2300 volt outdoor circuit breaker. This he can do either from within the station or at the substation. At the same time he can leave the station lights and outside auxiliaries in operation if required, since these circuits are not affected by tripping the outdoor breaker.

A fundamental consideration in establishing the control system was that of station attendance; it was decided at the start that: (1) In the interest of safeguarding property, each station must have attendance at all times; (2) During the tour of duty the attendant may be at any part of the station property, subject to prompt arrival at the control room upon signal; (3) In the simple booster stations the attendant will perform, singly, all operating duties incidental to starting, running and stopping units, as required by the central dispatching office (4) Maintenance work except of minor nature is to be handled by established maintenance personnel, progressing from station to station. In case of difficulty or failure in the operation of equipment, specialized repair personnel will be available on call to the superintendent of the division. These operating conditions determine the following essential features of the system of control: (a) Starting and normal stopping of the stations and of units within each station shall be controlled by the station attendant; (b) Protective shut-down of units and stations must be instituted automatically when conditions arise that exceed predetermined limits of safe operation; (c) In case of automatic protective shut-down, a signal must be given to inform the attendant that shut-down has occurred, and indication must be given of the specific protective function that caused shut-down; (d) In the starting and stopping of main line units, it is desirable to simplify the duties of the attendant by providing automatic operation in proper sequence for the valves, motor control and pressure devices concerned; the operator, thus relieved from performing a routine of manual operations at different points in the station, can devote his attention to the overall process and to the results obtained; (e) For continuous operation of the line it is, of course, necessary to maintain pressure conditions within the limits predetermined for protective shut-down, and this should be accomplished by automatic means.

The control system developed to meet these requirements embodies the coordinated application of pressure, temperature, and electrical control and indicating devices. Each pump unit normally is controlled from an individual "Start-Stop" pushbutton, the control system providing a predetermined sequence of operations. Considering a typical 2-unit booster station, this control system provides automatic means for: (1) Venting the pump casings during shut-down to prevent building up of pressure within them by leakage past suction or discharge valves; (2) Permitting the starting of a unit only upon existence of a predetermined minimum suction pressure; (3) Operating in correct sequence a motor driven suction valve and a motor-driven discharge valve for each unit; (4) Venting vapor from the pump casing, and circulating liquid through the pump, during starting; (5) Adjusting the station capacity to the line throughput while the station is on the line; (6) Limiting the minimum value of station suction pressure to a value safe for pump operation; (7) Limiting the maximum value of the station discharge pressure to a value safe from the standpoint of pipe line stress; (8) Safety shut-down, sounding the station alarm and lighting an individual indicating light, in case of excessive:

	See Fig. 4 Symbol
Duration of high motor starting current	SC-20
High motor winding temperature (alarm and light only)	MT-10
Power supply failure (alarm only—air operated)	SV-P
High motor bearing temperature (front or rear bearing)	MB-11, MB-12
High pump bearing temperature (front or rear bearing)	PB-11, PB-12
High pump gland temperature (front or rear gland)	PG-11, PG-12
High pump casing temperature	PCT-10
Low suction pressure #1 and #2 pumps	PS-11, PS-21
High suction pressure #1 or #2 pumps	PS-12, PS-22
High station discharge pressure	PS-5
Low station discharge pressure	PS-6
Low air supply pressure to hydraulic controllers (alarm and light only)	PS-A2
Low station air supply pressure (alarm and light only)	PS-A1
High sump tank level (alarm light and pump shutdown)	S L

An ammeter (A-20) and ammeter switch are provided for each unit, also a common temperature indicator (TI-20) for both units with a selector switch for each unit whereby the temperature indicator may be connected, per unit, to any one of:

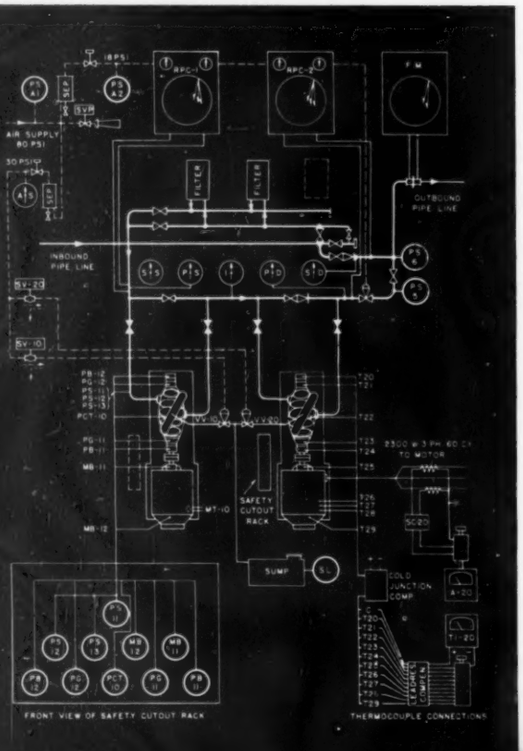
	See Fig. 4 Symbol
2 pump bearing thermocouples	T-21, T-25
2 pump gland thermocouples	T-22, T-24
1 pump casing thermocouple	T-23
2 motor bearing thermocouples	T-26, T-26
3 motor winding thermocouples	T-27, -28, -29

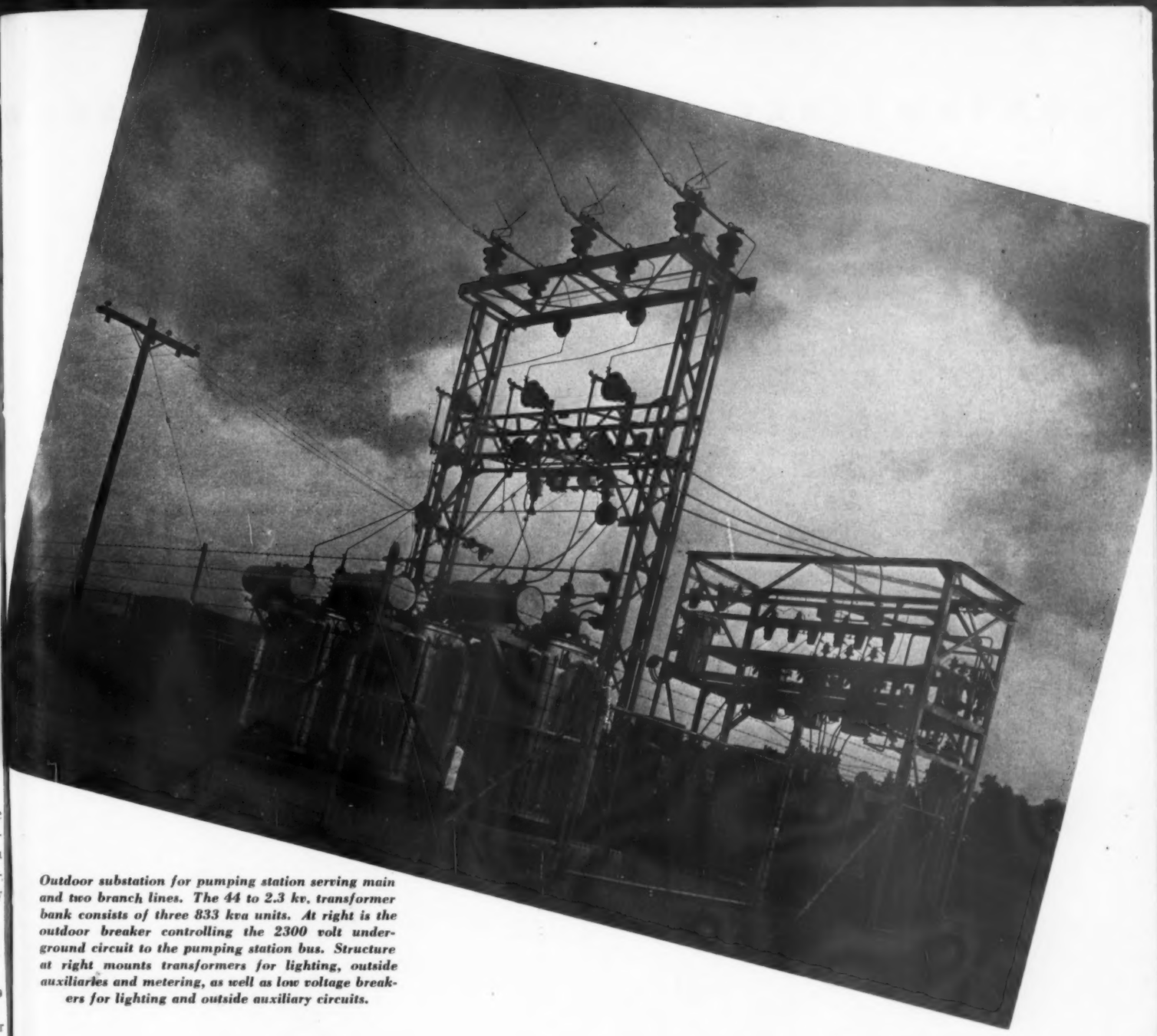
The gauge panel mounts a flowmeter (FM) for indicating and recording the rate of flow at or by the station, also two pressure controllers (RPC-1, RPC-2) whose function will be discussed below, and six gauges indicating pressure at the following points:

	See Fig. 4 Symbol
Station suction	SS
Pump suction	PS
Inter-pump	IP
Pump discharge	PD
Station discharge	SD
Air supply to air operated vent valves	AS

Each pump has a connection from the top of its casing through a vent valve to the station sump. The vent valve (VV-10, VV-20) is spring-opened, air-closed, the air supply being controlled by a 3-way solenoid valve (SV-10, SV-20). This valve is so connected in the motor control sequence that the vent valve is open while the pump unit is down, and remains open during the starting cycle until the pump discharge valve is fully open, whereupon the solenoid valve is energized

Fig. 4. Below: Schematic diagram of station control system, for typical two-unit station.





Outdoor substation for pumping station serving main and two branch lines. The 44 to 2.3 kv. transformer bank consists of three 833 kva units. At right is the outdoor breaker controlling the 2300 volt underground circuit to the pumping station bus. Structure at right mounts transformers for lighting, outside auxiliaries and metering, as well as low voltage breakers for lighting and outside auxiliary circuits.

to close the vent valve. In a shutting down cycle, when the pump discharge valve leaves its open position, the solenoid valve is de-energized to open the vent valve. At the conclusion of the shutting down cycle both the discharge valve and the suction valve are closed, and flow through the pump venting system ceases.

The regulation of station pressure is accomplished by air actuated instruments such that the station suction and discharge pressures can be automatically maintained at any predetermined values. The control valve which is actuated from these instruments is normally automatically controlled, but is equipped for manual operation in the event of air failure or interruption of electric service at the stations. All the stations operating in a continuous section of line are affected by any change in flow rate that may occur. There are many changes in flow rates throughout the entire system. These are occasioned by the existence of the large number of delivery points or terminals, which may be utilized for multiple deliveries or for single full-line capacity deliveries. The station pressure controls are so designed as immediately to adjust each station to these varying flow conditions, and thereby maintain uninterrupted operation. The previously mentioned automatic shut-down features are coordinated with the regulating equipment so as to permit operation of the control system over its full range and only to prevent operation of one or two units in the station in case the pressures exceed pre-established limits.

Physically the control for each station centers in a control desk in the control room, where also is situated the gauge board previously mentioned, the attendant's working desk, and a teletype operating over a circuit serving the system dispatcher's office and all pumping stations. Red indicating lights on the control desk identify the functioning of each of the protective shut-down and alarm switches already mentioned. Amber and green indicating lights show respectively the open and closed positions of the motor-operated suction and discharge valves, and of the principal manually operated valves in the station piping. To clarify the function of each device the desk top bears a schematic layout of the principal piping for the particular station, and in this piping diagram the indicating lights, temperature indicator, ammeters, selector switches, and push-buttons are all mounted in appropriate position. An accompanying illustration shows how conveniently the control desk and gauge board in one of the stations serves as the central point for indication and control of all principal station functions. This illustration on page 32 shows the control desk, gauge board and teletype.

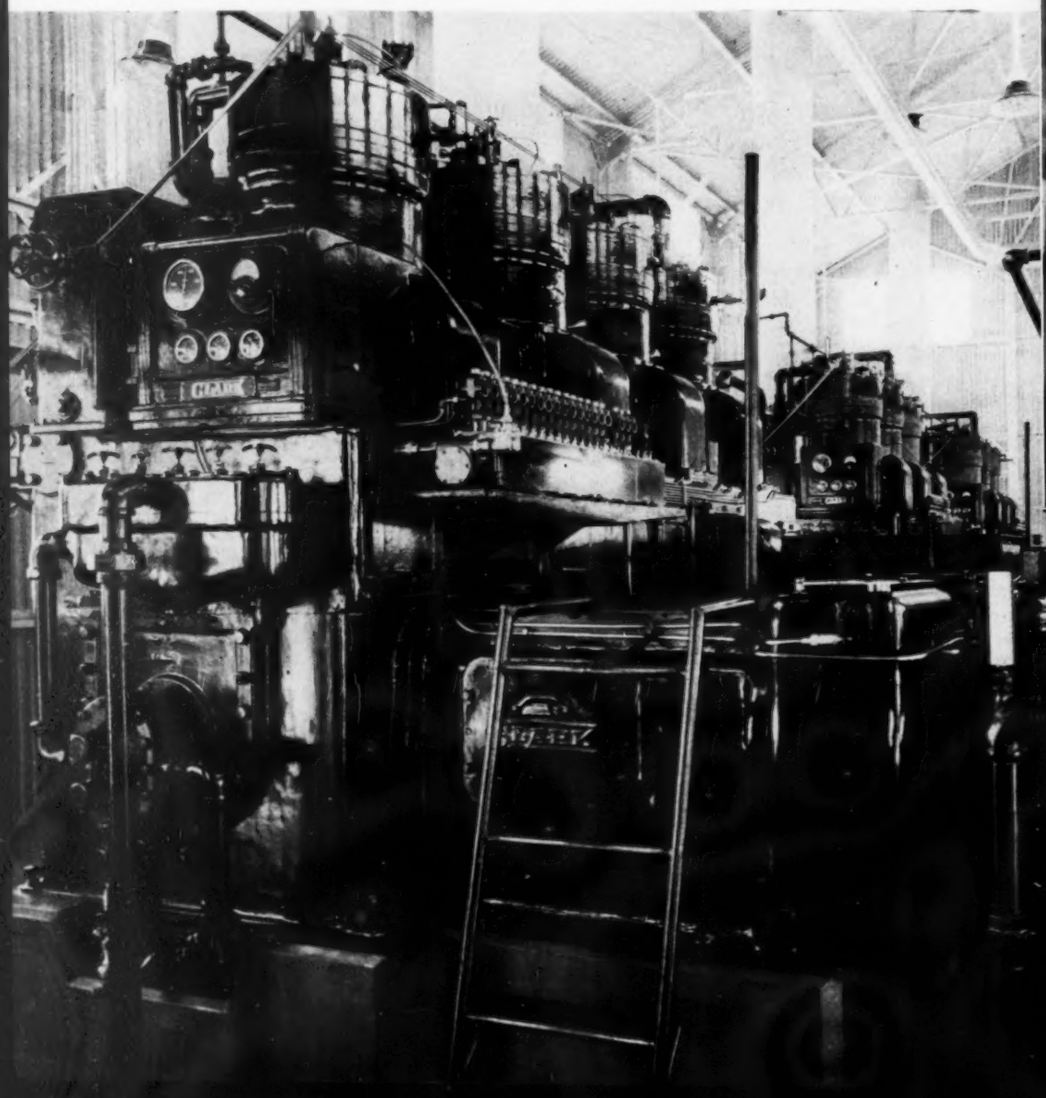
CONVERTIBLE DIESEL-GAS COMPRESSOR

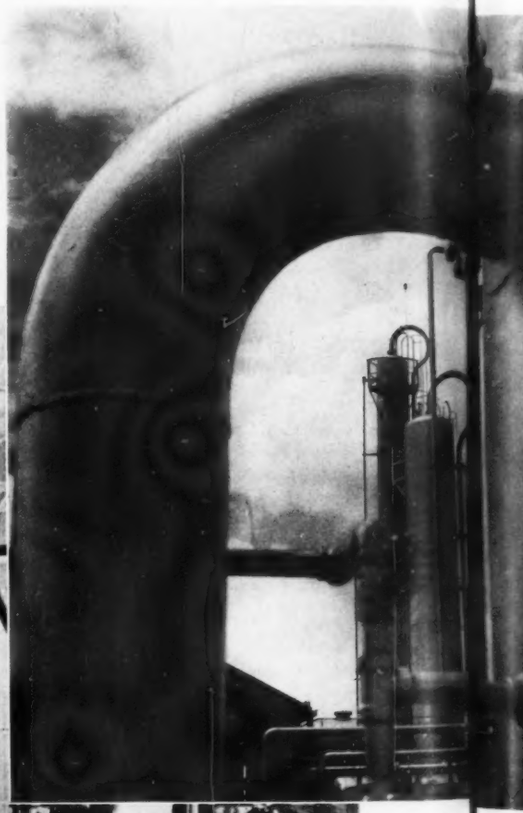
At Luby, Texas

By William H. Gottlieb

OIL FIELD operators were among the first to recognize and utilize the advantages of the natural gas internal-combustion engine, and continuous improvements in engine design have kept this type of equipment in the forefront as a power producer wherever the fuel is obtainable. The convertible Diesel-gas engine introduces an element of flexibility which further enhances the value of these units. It was natural, then, when one of the major oil producers erected a gasoline plant in the Luby Field, Texas, in 1939 that it should choose the most modern, efficient power units for the major work of compressing the gas from which gasoline was to be stripped. For this continuous, heavy-duty service the engineers installed three of the new gas engine, angle-compressor units. Two of these Clark compressors have three power cylinders each, and each set of power cylinders drives two, 24 by 14-in. compressor cylinders. The third engine has four power cylinders driving two, 24 by 14-in. compressor cylinders and one 7 by 14-in. recompressor cylinder. Each power cylinder is rated at 100-hp. at 200 r.p.m. The power cylinders are in line vertically and this vertical gas engine drives horizontal compressors connected to the same crankshaft. This compact arrangement makes for easy installation, simple maintenance and a high over-all efficiency.

All the gas that enters the plant, 9,000,000 cu. ft. a day, is handled by the compressors. Coming in from the wells through two, 16-in. main gathering lines, the gas passes through a scrubber for removal of distillate and reaches the compressor intake through lines from a 20-in. overhead header just outside the power house. The gas comes to the compressors at a 7-in. vacuum and is discharged at 45 lbs. pressure into a common 20-in. line in a concrete box outside the plant. After passing through the coils of one section of a large atmospheric-type cooling tower, the gas reaches an absorber where lean oil takes from the gas the gasoline it carries. The denuded gas flows out through a residue line from which the supply of engine fuel is drawn. Besides supplying the engines, gas is used for boiler fuel and for domestic use in the camp, and the remainder is burned by two waste flares. From the absorber the rich oil enters the still where hydrocarbons are flashed off and the denuded oil returned, through heat exchangers and cooling tower, to the lean oil suction. From the outlet oil line of the main still, a quarter inch line draws part of the oil to a small still heated by steam and electricity where the lighter portions of the absorption oil are flashed off and the heavy substances discharged to the sewer. In the course of operations, this cleans the entire absorption oil supply. Vapors from the main still are condensed in a battery of coolers and returned to an overhead tank. The refluxing medium for the still is taken from this tank and the balance of the liquid is fed to the stabilizer. All excess gas is returned to the power house





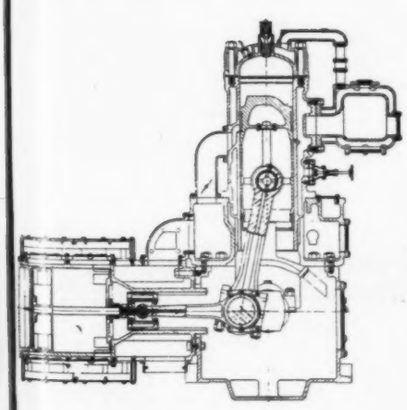
where the recompressor raises its pressure from an inlet of 25 lbs. to a discharge pressure of 175 lbs. The higher pressure keeps the lighter hydrocarbons in fluid which enters the stabilizer at the top charge line. Vapors from the stabilizer are cooled and returned to a tank which supplied refluxing medium for the stabilizer while the rest passes to the butane storage tank where it is weathered to 70 lbs. pressure and sold as commercial butane. Gasoline leaving the stabilizer is cooled and stored in the five 30,000 gal. storage tanks to await delivery by pipeline to the refinery.

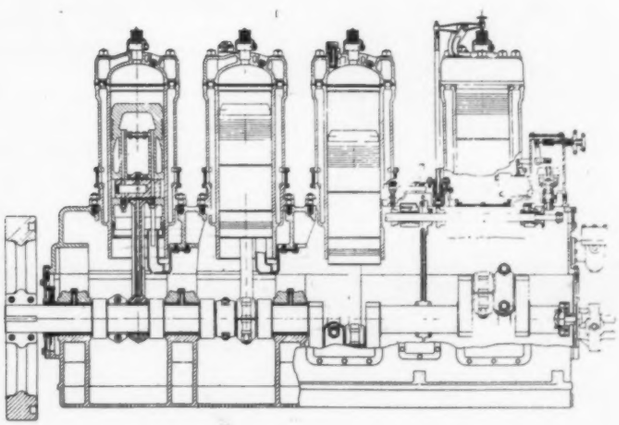
Gas in the residue line is kept at 28 lbs. but a regulator reduces pressure of the engine fuel supply to about 16 lbs. At this pressure the gas enters the power cylinder through a fuel injection valve just as the piston, moving upward, has closed the intake and exhaust ports. Thus, there is no loss of gas. The mixed air and gas charge is compressed until finally ignited by the magneto system. Effective scavenging of the cylinders is insured by a double acting air pump driven from the crankshaft of each engine. This scavenging cylinder pumps air into a manifold within the crankcase at about 3½ lbs. pressure. As the piston nears the exhaust ports burnt gases are allowed to escape and pressure to drop to atmospheric. Then the air inlet ports are uncovered and scavenging air at 3½ lbs. pressure rushes into the cylinder in such a manner that it sweeps out all exhaust gas and charges the cylinder with fresh combustion air. Air for each engine is cleaned in an oil-bath type filter located outside the plant before reaching the scavenging pump. The hot exhaust gases exit through a water-cooled header which leads to a vertical silencer extending up through the roof.

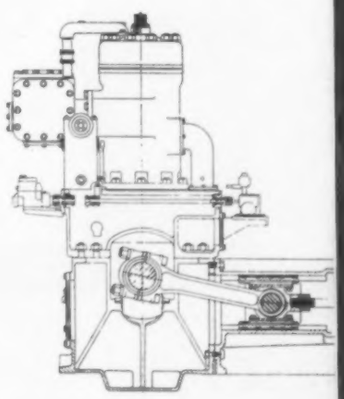
All bearings are lubricated by a pressure system. A gear pump driven from the crankshaft takes oil from the crankcase and puts it through a duplex filter, a cooler, and then into a header within the crankcase. From the header the lubricant flows under pressure to the main bearings, then up the drilled connecting rods to the wrist pin bearings. The same oil is forced up into the piston crown to serve as a cooling agent, returning through a downspout to the base of the crankcase for recirculation through the lubricating system. Both power and compressor cylinders are lubricated by a force feed mechanical lubricator which supplies oil to three points on the perimeter of each cylinder. In addition, each engine is equipped with a one-shot lubricator serving the fuel injection valves. It is the practice at this plant to drain the crankcase once a year, putting in a fresh supply of new oil. Only water obtained from condensing exhaust steam is used in the closed cooling system. The soft water flows by gravity from a surge tank to the suction of two 650 gal. per minute centrifugal pumps which send it through coils in the large cooling tower, then through the engine jackets back to the tank. Two 2000 gal. per minute centrifugal pumps put raw water over the tower. Even the raw water is treated to protect coils, pumps, and spray nozzles. Since steam is required in the stripping process, it was decided to utilize steam to drive all the pumps and to supply lighting. To supply these needs, the plant has five 125-hp. locomotive-type fire-tube boilers. Each pump is driven by an individual turbine. Makeup for the raw water supply and water for use in the camp is drawn from a well by a centrifugal well pump driven through right-angle gears by natural gas engine. The gas engines are protected against injury through failure of cooling water or lube oil pumps. If the water pump discharge pressure drops 25 lbs., a whistle sounds, warning the operator. If no action is taken and the pressure drops down to 10 lbs., the magnetos are grounded, stopping the engines. There are also switches arranged to ground the magnetos if lube oil pressure drops below 15 lbs. or if engine speed rises above 325 r.p.m. A gauge board on each engine holds an exhaust pyrometer, a tachometer, thermometers and pressure gauges. Engines are started by compressed air and each power cylinder is equipped with a starting valve. Air is supplied by a two-stage, locomotive-type, steam-driven compressor. Low pressure air is put through a section of the cooling before reaching the high-stage compressor cylinder.

Oil field operation is frequently a continuous and arduous service for a power plant. This 1000-hp. engine compressor plant was designed to handle 9,000,000 cu. ft. of gas each 24 hours but the load has been known to go as high as 10,500,000 cu. ft. In the entire life of the plant there have been no enforced shutdowns and no repairs whatsoever. Once a year each engine is given a thorough inspection. At the latest check, there was no noticeable wear in either cylinders or bearings. In this plant at present, there is no incentive to economize on fuel since any saving in engine consumption would only need to be burned by the waste flares. Yet, the increasing utilization of waste products someday may make it advisable to conserve the fuel supply and the company may then have the full advantage of economical engine operation.

Far left, three Clark angle compressors with a total horsepower of 1,000 supply all power for compressing gas at a gasoline stripping plant in the southwest. Left, intake gas line leading into scrubber through which may be seen the absorber, still, and stabilizer. Below, cross-sectional views of four-cylinder Clark gas engines used in the compressor plant; vertical natural gas engines drive horizontal compressors, power transmission can be obtained by the connection of compressor and engine pistons to the same crankshaft.







PROPOSE INCREASE In California's Heavy OIL PRODUCTION

Report of Production Committee Outlines Plans for Well Rehabilitation and New Drilling in Proved Fields to Meet War Demands—Wildcatting Recommended to Maintain Reserves.

DEVELOPMENTS OF THE WAR have given to fuel oil, more particularly to the heavy type classed by the trade as residual fuel oil, a place of importance such as it never before has occupied. The operation of industrial plants engaged in the manufacture of war materials along with the expansion of naval activity and of ocean transport has called for rapidly increasing quantities of this fuel and has raised it from the position of a relatively little considered by-product of refining to one of primary importance to the war effort likely to be of increasing significance.

There are two possible ways of increasing the supply of heavy fuel oil both of which need to be employed to satisfy mounting military requirements. One is by altering established refining practice to reduce the yield of commercial gasoline so that a larger percentage of each barrel of crude will be converted into fuel oil. The other is by enlarging the output of heavy base crudes which naturally give a higher yield of this product. It is a fortunate circumstance for the nation in view of the intensification of war activity in the Pacific that the largest deposits of these heavy base crudes are located in California. In past years a surplus of these oils has been something of a problem to Pacific Coast producers but at the present time, with stocks declining and demand rising, they represent a national asset of tremendous value. The situation and its bearing upon the war is fully covered in a report submitted to the Office of Petroleum Co-

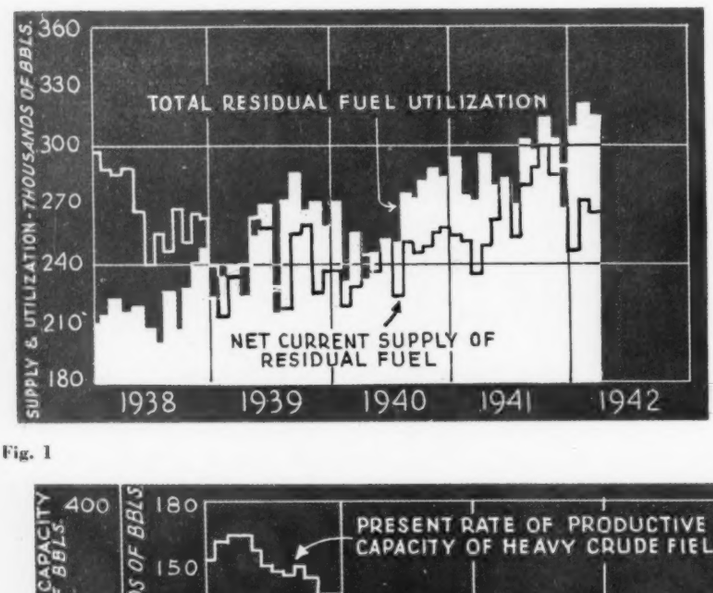


Fig. 1

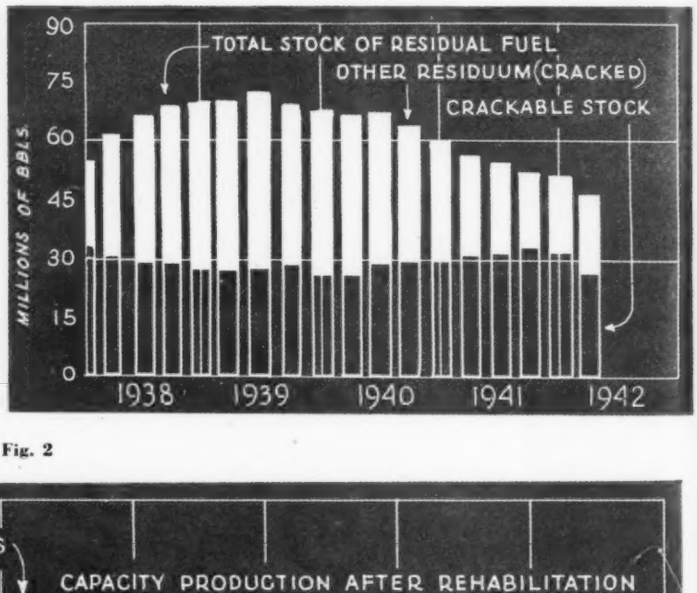


Fig. 2

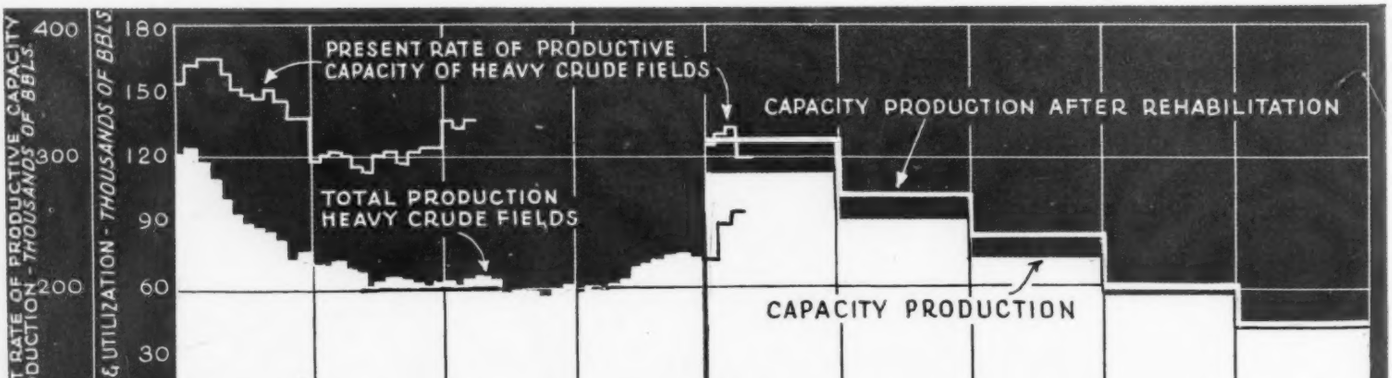


Fig. 3

ordinator a few weeks ago which shows in detail the steps needed to raise production to a level which will meet all estimated requirements for that area. Incidentally it affords another example of the abiilty of the American oil industry to neet unexpected demands of which so many have been placed upon it during the past few months.

Prepared through the joint effort of Pacific Coast oil producers and the OPC production committee for District No. 5 the report presents plans and specifications for increasing heavy oil production to the point where it can meet a daily demand of more than 300,000 bbl. with a minimum use of critical materials. This is to be accomplished in part through new drilling but in large measure through the rehabilitation of existing wells to increase their production. Salient features of the survey which is projected to cover a five year period to 1946 are given herewith:

California provides the only supply of petroleum west of the Rocky Mountains. The necessity for increasing this supply in a location so strategic to our war effort is paramount. Strong encouragement for material increase in all exploration activities is essential. The serious decline in the discovery rate of new fields and pools in the State of California, supports the belief that many more wildcat wells must be drilled if any of the remaining undiscovered oil fields are to be found in time to produce during the present emergency. A rate of discovery greater than 300 million barrels per year is necessary to meet the apparent war demands.

Heavy oil reserves of 75 fields and pools have been estimated as of January 1, 1942 at approximately 897 million barrels of oil, below 24 degrees gravity. These reserves represent underground storage from which the rate of withdrawal is limited by the maximum ability of the constituent wells, as now equipped, to produce. Of these developed reserves, some 479 million barrels, or 53 percent, are estimated as producible within the next five years. It should be noted that an average of 285,000 barrels daily is estimated as the productive capacity of the present wells, as now equipped, for the year of 1942, and that this rate declines to slightly less than 180,000 barrels daily for 1946. A total of 1439 wells are considered as projects for rehabilitation in the fields and pools surveyed. It is estimated that these wells will have an initial increase in production of 32,010 barrels daily, and had this work been done by January 1, 1942, the capacity production for 1942 would have been approximately 315,000 barrels daily. No appreciable increase in reserves is expected from rehabilitation work; a greater decline rate is to be anticipated, so that capacity production for 1946 is estimated to be 180,000 barrels daily.

A total of 8,248 tons of steel will be required to rehabilitate all proposed wells. Out of the total of 1,439 wells, which are considered projects for rehabilitation, 578 are now producing at rates limited by the equipment in place. Repair or replacement of equipment will permit these wells to produce at capacity. A substantial proportion of such increase can be obtained by the granting of practical exceptions to present restrictive regulations with the reallocation of materials and equipment now on hand.

Approximately half of the estimated total increase in production can be secured from these 578 wells, and will require 40 percent of the total steel proposed for the rehabilitation program. The remaining 861 shut-in wells furnish the other half of the estimated increase in production and will require 60 percent of the steel. Under the present economic conditions 799 idle wells cannot be considered as projects for rehabilitation. There remains in California sufficient proved acreage, productive of heavy oil, to

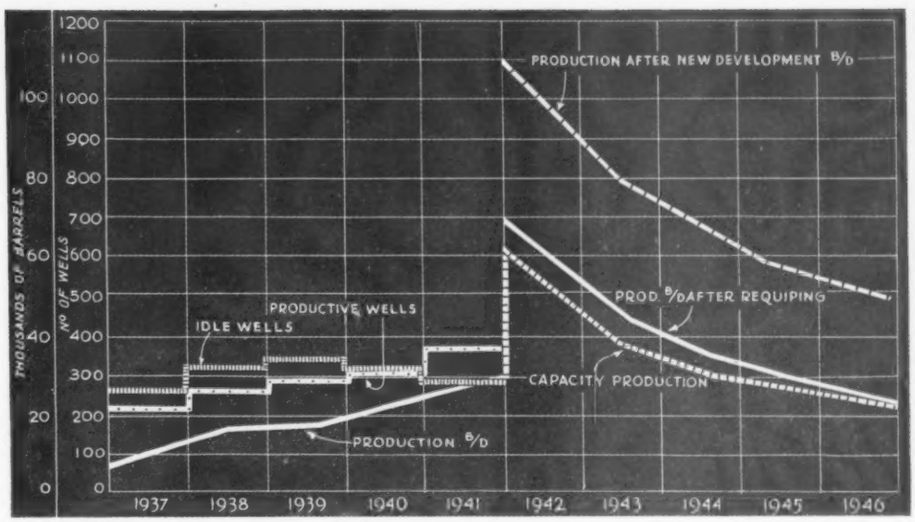


Fig. 4

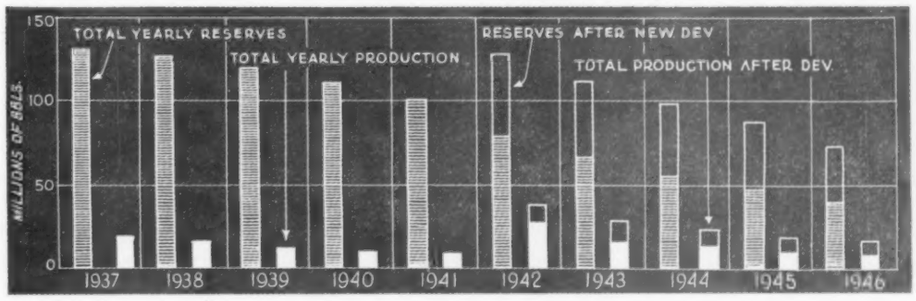


Fig. 5

Figs. 4 and 5. The present productive capacity of the Coastal Region is at least 50,000 bbl. daily. The sustained daily production of present wells from the area is approximately 30,000 bbl. daily.

The trends shown by Figs. 1, 2, 3 on opposite page indicate that the present rate of productive capacity of heavy fuel oil in California should be maintained at more than 300,000 bbl. per day. Since the normal annual drilling program in the heavy oil fields will not provide a sufficient number of wells to maintain this capacity development in these fields should be increased by approximately 80 percent in 1943.

permit drilling approximately 2,685 wells on proposed spacing patterns. The steel requirement is estimated to be 168,000 tons for the drilling of these prospective wells, or an average of approximately 62 tons of steel per well. The total oil production of these wells, made available over a five-year period, is estimated to be 214 million barrels, or an average of 117,144 barrels daily. The normal annual drilling program in the heavy oil fields will not provide a sufficient number of wells to maintain the productive capacity of 300,000 barrels daily. Consequently, the development rate in these fields should be increased about 80 percent in 1943. All restrictions on development of heavy crude, other than those not warranted through high steel factor, should be removed.

Oil is being produced at a more rapid rate than it is being discovered and demand for heavy oil

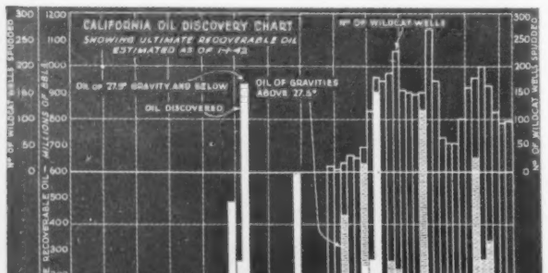

CALIFORNIA OIL DISCOVERY CHART
SHOWING ULTIMATE RECOVERABLE OIL ESTIMATED AS OF 1-1-43
OIL OF 27.9° GRAVITY AND BELOW
OIL DISCOVERED
OIL OF GRAVITIES ABOVE 27.5°
Nº OF WILDCAT WELLS
ULTIMATE RECOVERABLE OIL - MILLIONS OF BBLS.
Nº OF WILDCAT WELLS DRILLED

Fig. 6

Fig. 6. Graphic record of the history of oil discovery in California. Vertical white columns represent the total number of barrels discovered each year.

is increasingly greater than the supply. It is, therefore, recommended that: (1) Wildcat drilling be encouraged in every possible way and top priority assistance be given for the drilling of exploratory wells; (2) All economically producible wells be rehabilitated and equipped where necessary; (3) The development of undrilled acreage, in fields capable of producing heavy oil, be stimulated to meet the demand made on this most important source of fuel oil. Existing orders are uniformly restrictive in their control of oil field operations and do not permit preference to projects most capable of meeting war demands. The realization of these demands should be accomplished by granting timely, practical exceptions to the current orders.

Study indicates that the total product demand on the Pacific Coast will be over 700,000 barrels daily in 1942, which will approach the all time peak of 1929. The demand will be met by California production of all types of crude, with small additions or receipts from other sources. The required products will be made from these crudes and the relative amounts of these products will be extremely variable and not subject to prediction from the data derived in this study. It is true that whether the refineries process either light or heavy crude, the products yielded will depend to a great extent upon the facilities available and the process used. However, immediate objectives will best be served by producing, if possible, crude oil that will yield a minimum of gasoline and a maximum of heavy fuel. This objective will be modified by that amount of light crude which will necessarily be produced in supplying the demand for natural gas. In some cases the refiner will have no option and must use the crude available to meet the demand for products. Nevertheless, everything possible should be done to reduce production of commercial gasoline by using the highest percentage of crude petroleum of low gasoline content.

It is estimated that demand for "residual fuel" oil in the Pacific Coast territory will be greatly increased within the next twelve months. This demand, which at the present time is 314,000 barrels daily, already represents the largest part of the total demand for all petroleum products in the Pacific area and exceeds supply by 52,700 barrels daily. Actual utilization of "residual fuel" in the first quarter of 1942 was 45 percent of the total demand for all products and by the second quarter of 1943 it is expected to be 54 percent of the total. On the other hand, while the demand for gasoline constituted almost 32 percent of the total demand in the first three months of 1942, it is not expected to be more than 26 percent of the total by the second quarter of next year.

Figs. 1, 2 and 3 show the total utilization and net supply of "residual fuel" oil in the Pacific Coast territory, together with remaining inventories of that product. Total utilization includes all heavy fuel used for civilian or military purposes, plus shipments out of the area. Net supply is made up of net refined output, crude used as fuel and imports into the territory. Inventories of "residual fuel" were divided to show the amount considered by the Bureau of Mines reports as "crackable stock," and the remaining portion which is presumed to be cracked residuum. This latter may also contain some straight-run residuum, unsuitable for cracking, due either to its quality or its location with respect to refining facilities. It can be seen that demand for heavy fuel has exceeded supply during most of the past two and one-half years. This deficiency is reflected in a steady decline in inventories over that period, reducing the total above-ground reserves of "residual fuel" to 48,500,000 barrels on March 31, 1942. If the current deficiency of supply continues, those inventories will be exhausted in about two and one-half years, assuming that all of the oil in storage is suitable for use as fuel. Should some of it be unfit for use, which is now a known fact, or should the difference between supply and demand widen, the day of exhaustion of above-ground reserves will come much sooner. Considered from the standpoint of current demand, the present inventories would last 153 days if new supply were completely shut off and all of the stored oil were usable.

Demand for California crude oil during the next five years, under normal peace time conditions, probably would have varied between 225 and 250 million barrels a year. Under present war conditions, it is conceivable that demand may be as much as 300 million barrels a year. To supply this demand and to provide a desirable additional reserve, it is essential that California discover oil at a rate necessarily greater than 300 million barrels annually. The present war emergency and the strategic location of California require the expenditure of the effort, money and material necessary to accomplish this result. The rate of discovering new fields can be materially increased only by increasing the quantity and quality of exploration activities. Although California's remarkably thick and rich oil-bearing formations have in the past provided an abundant supply of new oil when sufficient effort and money were devoted to the search, present geological information supports the belief that even more wildcat wells must be drilled if many of the remaining undiscovered oil fields are to be found in time to produce during the emergency.

Exploration activity, including geological and geophysical work, land leasing, and the drilling of wildcat wells, costs money which normally must come only from revenue in excess of the cost of drilling for and producing oil. Increase in such revenue, essential to increased activity in exploration and geological research, is not in sight for the oil operator who must pay rising costs for labor and material, extremely high taxes to county, state and federal governments, and unreasonably high oil royalty to landowners, if, as is now the case, he obtains less oil per day from curtailed or declined production and sells his oil or his refined products at present reduced prices.

There are 13,311 wells in the state potentially capable of producing heavy oil.

Wells capable of production (effective wells)	**11,651**
Shutdown (ineffective) wells	**861**
Idle wells (ineffective wells which cannot be economically rehabilitated)	**799**
Total	**13,311**

Of the producing wells 578 require changes in equipment or redrilling to obtain maximum production. This work in a great many instances cannot be done because of the provisions of Conservation Order M-68. In a few pools minor changes will effect very substantial increase in production. Producing wells that require redrilling will demand more steel per barrel of increased production than the average shut-down well.

The 861 ineffective wells proposed for rehabilitation are estimated to have a capacity production of 15,000 barrels daily, and will utilize 5,000

tons of steel. These wells have been shut-in for a number of years, some since 1927. It is safe to assume that there has been much deterioration of subsurface equipment, the extent of which cannot be known until remedial work is started. Also, it is likely there will be a number of casing failures in the first few months of operation due to the vibration of pumping on subsurface casing strings weakened by corrosion. Redrilling will not be warranted on most of such wells under present economic conditions. The 799 idle wells which cannot be economically rehabilitated, constitute the remainder of the ineffective wells. It is probable that most of these wells should be abandoned and all casing and other material salvaged for use which is more essential to war effort.

A total of 1,439 wells are subject to rehabilitation.

Wells capable of production (effective wells)	578
Shutdown (ineffective) wells	861
Total	1,439

The rehabilitation of these 1,439 wells will secure an estimated initial production increase of 32,010 barrels daily and an estimated 5-year recovery of 28,986,000 barrels. The total steel required for this rehabilitation is estimated at 8,248 tons, resulting in a steel factor of 3,510 barrels or recovery in five years per ton of steel. Wells suitable for rehabilitation were selected on the basis of a minimum steel factor of 0.5 barrels daily per ton of steel used. An attempt was made to classify these wells according to economic desirability: First, projects definitely profitable under present conditions; and second, marginal projects or those of questionable profit under persent conditions. However, due to insufficient cost data and in order to have a consistent classification, the following basis was used: Group 1. Wells on which the production increase was two barrels daily or more per ton of steel required. Group 2. Wells on which the production increase was 0.5 barrels daily to 1.9 barrels daily per ton of steel required. On the basis of this classification, the following distribution was made on the 1,439 wells subject to rehabilitation:

	No. of Wells	Prod. Increase B/D	Steel Required Tons	Steel Factor B/D per ton of Steel
Group 1	855	27,835	4,219	6.60
Group 2	584	4,175	4,029	1.04
Total	1,439	32,101	8,248	3.88

Although attempts were made to estimate the cost of all proposed rehabilitation, estimates were secured on only 320 of the 1,439 wells. These data were analyzed and classified according to the rehabilitation cost per barrel of oil recovered during the first five years, thereafter. These unit costs compared with the 5-year recovery on a cumulative basis from the lowest rehabilitation cost per barrel to the highest, indicated the following general conclusions: (1). Fifty percent of the 5-year recovery can be secured at a rehabilitation cost not to exceed five cents per barrel. (2). Sixty percent of the 5-year recovery can be secured at a rehabilitation cost not to exceed ten cents per barrel. (3). Seventy percent of the 5-year recovery can be secured at a rehabilitation cost not to exceed 20 cents per barrel.

The above conclusions as to rehabilitation costs are based upon limited data and are subject to considerable revision when more complete data are available. There is an approximate correlation between rehabilitation costs and steel demand so that if selection of rehabilitation projects is made on the basis of relative steel factors, this will tend to give preference to the lowest cost production.

As the rehabilitation of heavy crude wells is the quickest means of securing additional heavy oil production, and as many of the proposed projects require a relatively small amount of steel to secure this additional production, the following recommendations are submitted: (1). That all applications for exceptions to Conservation Order M-68 covering the rehabilitation of shutdowns or producing wells, be immediately approved provided the steel factor is not less than 1.0 barrels daily per ton of steel, or 1000 barrels of 5-year recovery per ton of steel. (2). That paragraph (c) (1) of Conservation Order M-68 and paragraph (a) (14) and (a) (15) of Preference Rating Order P-98, be amended or reinterpreted as follows: Those provisions relating to replacement, maintenance and repair be altered so that no application for exception will be required for rehabilitation on existing wells in order to maintain or restore the normal production from such wells, regardless of the bookkeeping methods used in accounting for the cost of such rehabilitation.

In most of the heavy oil fields under consideration, the viscosity of the oil is high, the accompanying gas is low in amount, and reservoir pressures are not maintained by water drive. Sand characteristics are not uniform, and sand bodies are not continuous due to lenticularity and faulting. Because of these conditions, field-wide migration of oil is a very remote possibility and local migration is distinctly limited. Much of the decline of productivity of the undrilled areas of these fields is due to regional migration of gas and dissipation of water head with consequent lowering of pressures. In settled fields, because of low reservoir pressures the rate at which the oil reserves can be produced is proportional to the number of producing wells and therefore to increase the availability of the reserves for this war it will be necessary to provide an increased number of wells. This should be done where it is postible to estimate a high future recovery of oil from a well, even if at a very low rate in barrels per year. California heavy oil fields require close spacing in order to produce a high percentage of the recoverable oil in the ground in a reasonable period. Oil that cannot be procured in the next few years, say five to be definite, will be of little value to the present war effort. Therefore, wells should be drilled on a pattern such that the density may be increased from time to time as the demand for the oil from a particular region or district is above productive capacity. It is logical to drill wells closely spaced if oil is in demand and to space widely where the production is required to be curtailed because of lack of market.

A total of about 2685 wells which will produce heavy oil remain to be drilled in California on proved oil land. The number estimated is considered to be that from which sufficient oil can be recovered to return the required investment. There are other wells that could be economically drilled if the price of oil were materially increased but the majority of these would not be worthwhile when the utilization of steel is considered. Until total reserves are greatly depleted, an expenditure of 40 tons of steel in a shallow well that would produce 10,000 barrels in five years, one ton of steel for 250 barrels of oil,

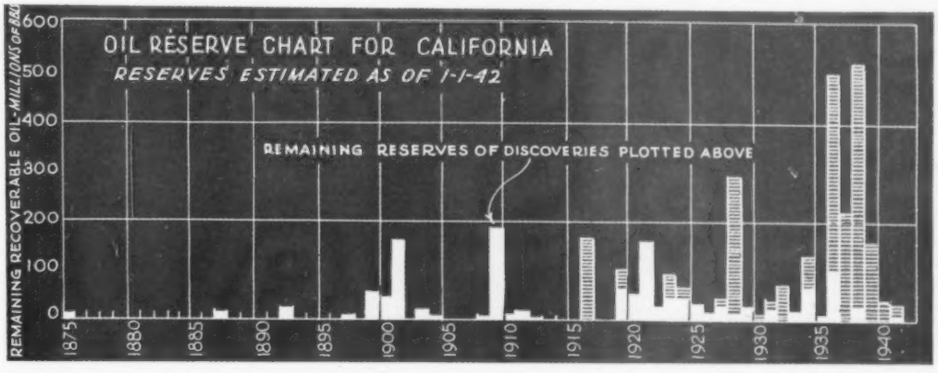


Fig. 7

Fig. 7. Oil reserve chart, showing estimated California reserves as of January 1, 1942.

would not be justifiable even if the price of oil were sufficiently high to return the cost in five years. Increased drilling that would result from high-priced oil would be best diverted to exploratory work, rather than to the development of areas of small productivity. Steel for the drilling of the proposed wells would amount to 168,000 tons or an average of about 62 tons per well. This is a minimum figure and in order to meet this figure, it will be necessary to exercise rigid control over tankage, line pipe and casing sizes and weights.

A total of 213,789,000 barrels of oil, or an average of 117,144 barrels daily, can be made available over a 5-year period, by the program outlined above. Excluding coastal areas, the amount is reduced to 147,055,000 barrels, or an average production of 80,578 barrels daily. The production shown for 1942, i.e., 60,750,000 barrels, or 166,439 barrels daily, is based on the assumption that all wells would be drilled simultaneously and completed this year. The figure 110,249 barrels daily shown for 1943 is more nearly representative of what could be done if drilling were to be started in 1942 and continued through 1943. The initial settled production of the average well considered is about 60 barrels per day; therefore, about 1650 wells would have to be drilled to increase the state production of heavy oil by 100,000 barrels daily. Exclusive of the Coast Region, the most prolific large areas suitable for intensive development are the Wilmington field for the Los Angeles area refineries and Mt. Poso-Round Mountain fields for San Francisco area demands. By selective drilling in such areas, it will be possible to obtain a production of 100,000 barrels daily from less than 1000 wells. Consideration should be given to a development program in the Elk Hills Naval Petroleum Reserve, which would make it available as an emergency source of production.

Other figures given in this report indicate that the rate of productive capacity of heavy oil, i.e., 300,000 barrels daily, should at least be maintained. If this is correct, the state will be short of oil, from all existing wells, in the following amounts, in the years as indicated.

	1943	1944	1945	1946
Estimated Demand—				
Barrels Daily	300,000	300,000	300,000	300,000
Estimated Production —Barrels Daily	270,532	234,295	204,227	177,814
	29,468	65,705	95,773	122,186

A logical drilling program to include all wells considered in this report, except those in the Coastal Region, would be as follows:

1942	500 new wells (23.9° grav. and less)
1943	900 new wells (23.9° grav. and less)
1944	800 new wells (23.9° grav. and less)
Total	2,200 new wells (23.9° grav. and less)

Well completions in past years have been as follows:

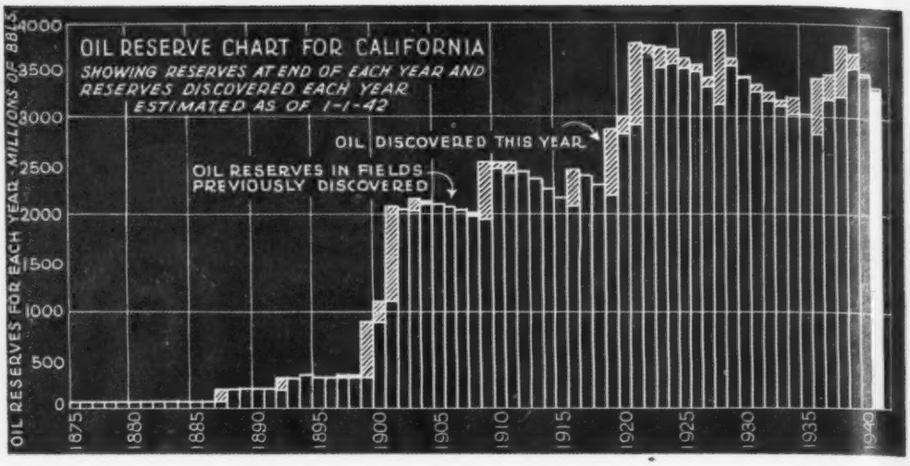


Fig. 8

Fig. 8. This chart shows the average annual rate of discovery for the past 20 years has been 207 million barrels, slightly in excess of the average demand for this period but less than the 1914 demand of 230 million barrels.

Number of Wells Producing

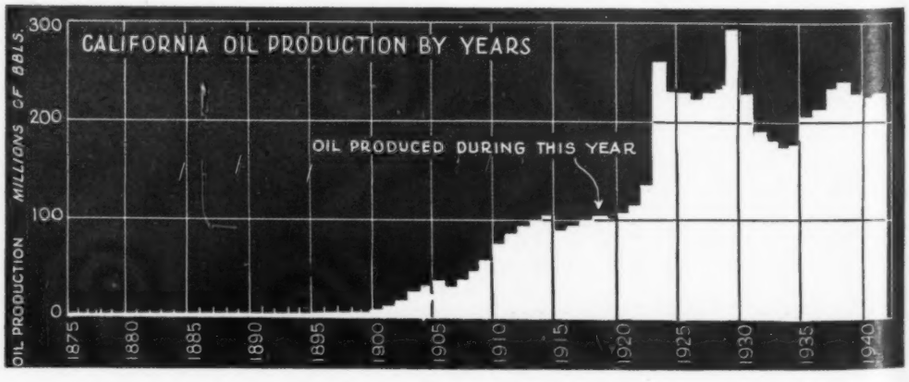
	23.9° and less	24.0° and over	Total
1940	326	521	847
1941	485	436	921

It will be noted from the foregoing that a normal yearly drilling program in the heavy oil fields will not provide a sufficient number of wells, but that the number of wells will have to be greatly increased, about 80 percent over the figure for 1941-1942, unless new flush fields are discovered. Such discoveries will, of course, increase the average initial production per well and decrease the number of wells required. Plans for the development of the Coastal Region may best be deferred until the necessary refining and pipe line facilities are worked out in detail. At the present time and under present conditions there is sufficient oil available to provide for that particular demand.

The report lists selected California oil fields arranged by regions in order of merit for future development. The merit factor is the number of barrels of oil that can be secured in five years for each ton of steel used. The number of acres per well shown in the table is based on past practice modified by the need to increase the rate of productivity, of the present reserves of heavy oil.

It is suggested in all shallow to medium depth heavy oil fields that: (1). A pool in the primary development stage be drilled one well to 10 pool-acres, but that the well spacing pattern allowed provide for secondary development of one well to five acres. (2). Old pools with undrilled areas be developed in a like manner. (3). Undrilled single locations in old pools be drilled on a pattern corresponding to uniform spacing already prevailing. (4). In drilled areas of old pools where closer spacing is justified by the amount of remaining reserves and the steel factor, the spacing for additional drilling be variable to allow for structural, sand and drainage conditions.

Fig. 9



Tube rolling for tight joints

Information supplied by "World Petroleum"

The high pressures and temperatures of present day refining demand tight, properly rolled tube joints, making the choice of the type expander used of great importance. Due consideration should be given to the composition of the tube, wall thickness, serrations and depth of Peoder section.

Adequate shear points are required to lock the tube securely into the header or flange; and tubes must be lined up level to flange or header to secure uniform metal thickness and prevent uneven shear points and tube splitting.

The header should be thoroughly cleaned; no grease or oil should remain on the surface or in the serrations. Expander lubrication is essential. Fibrous grease should be applied to rolls, cages and mandrels at the start of operations. Frequent cleaning of the expander tool in distillate is recommended to remove mill scale, etc.

Expander tools include well proportioned thrust mechanisms with micrometer adjustments, lockable into position to prevent over-rolling. Reaching the rolling depth, forward movement of cage and mandrel stops, while continued tool rotation irons out remaining ridges in the roll and produces a mirror-like finish.

CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.
MOLYBDIC OXIDE—BRIQUETTED OR CANNED • FERROMOLYBDENUM • "CALCIUM MOLYBDATE"

MOLY

Climax Molybdenum Company
500 Fifth Avenue • New York City

WORLD PETROLEUM ABSTRACTS

Summaries of the Most Important Articles as Published in the Oil Press of the World Dealing with Technical and Economic Aspects of the Petroleum Industry — Edited by Dr. O. W. Willcox.

DRILLING

Instrument for Determining the Direction of Dip in Cores Taken in Inclined Holes—C. F. C. Moore and N. F. Brown in JOURNAL INSTITUTE PETROLEUM, Vol. 27 (1941), No. 216, pp. 419-424.

The determination of the direction of dip as shown in a core with respect to north can be made with fair accuracy—in all but vertical wells—by correlating the core with the direction of deviation of the well, which in turn can easily be determined by the single-shot type of inclinometer.

A simple method of correlation is to obtain an acid-etch in a glass bottle attached to the core with its long axis parallel to the core-barrel; the low-point of the etch will then indicate the direction in which the well is deviating. An instrument to obtain such an etch is described.

The core is obtained with a conventional core-barrel, preferably of the non-rotating type, in the normal manner. At a pre-determined time coring is stopped, and the instrument, which is run inside the core-barrel, attaches itself to the top of the core. After a short interval the core is burnt-in, pulled, and carefully extracted from the core-barrel.

By means of suitable circular protractors, the dip in the core is correlated with the low-point of the acid etch, and hence with true north by correlation with the single-shot inclinometer reading.

This instrument was designed and built for the Indo-Burma Petroleum Co. for a solution of a drilling problem presented by steep dips, possibly associated with faulting (other instruments being unavailable at the time and place). In this emergency it presented no operating difficulty and gave reproducible results.

Rotary Drilling in the Appalachian Area—E. H. Tollefson and W. W. Mayfield, before AMERICAN PETROLEUM INSTITUTE, PRODUCTION DIVISION, EASTERN DISTRICT, Pittsburgh, April, 1942.

Six deep wells have been drilled with rotary tools in the Appalachian Area, which is essentially a hard rock drilling country. Drill pipe and rock bit performance is the main factor to consider in determining the practicability of using this method of drilling. Experiences gained from these wells indicate that this method can be successfully used for wells of 6,000 feet or more. Reasons for using rotary drilling in this area are: (1) saving of time, (2) saving of casing, (3) directional control of hole, (4) certainty of completion, and (5) effective control during completion.

Costs of the wells drilled to date have been excessively high because of adapting this method of drilling to a new area and because of transporting rigs from long distances. Cost analyses indicate that for future wells the total actual drilling cost, excluding casing, will be about $8.00 per foot for 7,000 foot wells through the Oriskany sand. Elapsed time for completion is about 90 days.

Detailed accounts of the drilling of these wells are given in the paper.

OPERATIONS

Survey of Fuel Consumption at Refineries in 1940—G. R. Hopkins, in BUREAU OF MINES REPORT OF INVESTIGATIONS No. 3607, January, 1942.

The average heat requirement per barrel of crude processed in the United States rose from 555,000

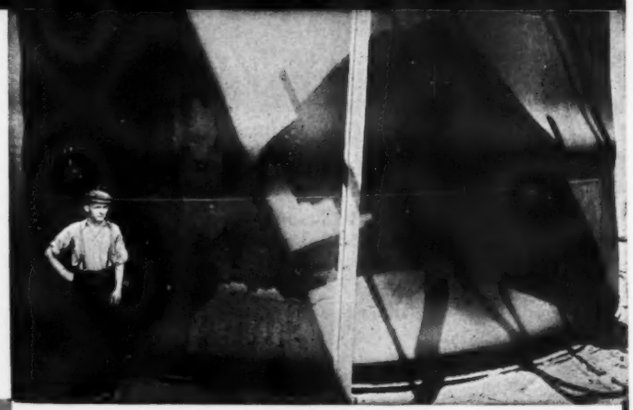
THE 'HITLER' TEST FOR WELDS

Proof of the soundness of Oxley welded construction lies in these photographs of tanks, subject to damage by enemy air attack.

In the upper photograph the depth of liquid in the tank was 37' 6" and, notwithstanding some distortion of the plates, there were no leaks at the welded seams.

In the second photograph the tank was severely damaged, but again the welds held on the distorted plates.

Both tanks have since been repaired by Oxley.



OXLEY
ENGINEERING CO. LTD.
HUNSLET, LEEDS
'Phone : 27468 (3 lines)
'Grams : "OXBROS, LEEDS."

RB H.W.

B.t.u. in 1939 to 579,000 B.t.u. in 1940, although crude runs increased from 1,237,840,000 barrels to 1,294,162,000 barrels in that period. Thus the almost invariable rule that the average amount of heat needed to refine a barrel of crude oil declines when total runs to stills increases was broken.

The reasons underlying the apparent loss in fuel efficiency in 1940 are quite obscure. There is little question but that the principle of heat exchange, the most important fuel saver, was used as extensively in 1940 as in 1939. A few companies replaced purchased power with electricity made at their plants, but for the country as a whole purchased electricity increased 7 percent, as compared with a 5-percent gain in crude runs to stills. Furthermore, the premise—the more complex the products the more fuel required—does not hold, as the yield of "complex" products, including gasoline, declined in 1940.

On the other hand, there were several developments in 1940 that tended to increase fuel requirements. In the first place, the output of aviation gasoline, a product requiring more over-all heat units per barrel, probably increased several fold in 1940 over 1939. Next, and perhaps more important, many refiners expanded their operations in thermal reforming, gas reversion, and other light-end processing as a means of maintaining their position as to gasoline quality. This factor not only was responsible for part of the increase in total heat required but was a contributory cause of part of the decline in yield of gasoline, a "complex" product. It has also been suggested that the expansion in operations in 1940 brought some inefficient units into operation. It is doubtful if this was a primary factor in 1940 as the refiners operated at about the same percentage of capacity both in 1939 and 1940, but it undoubtedly became of real importance in 1941, when many refiners utilized all equipment, regardless of obsolescence.

New Type Secondary Recovery— Victor Kotschnoubey, in OIL & GAS JOURNAL, Vol. 40 (1942), No. 43, pp. 39-40.

The old Dupo field in St. Clair County, Illinois, had reached a point where an operator using a beam pump to lift 3000 bbl. of fluid a day was recovering practically no commercial oil. Then a change was made to an electrical centrifugal pump which lifted 5,800 bbl. of fluid a day; within a week the well was yielding 100 bbl. of oil, and in three weeks reached a peak of 365 bbl. a day and is still a good producer. This led to installation of Reda submersible electrically driven centrifugal pumps in other wells (after acidizing and shooting) and the production of the field as a whole became quite satisfactory.

The explanation apparently is that the water zone was being replenished by formation inflow at such a rate that the low-capacity pumps could not draw the oil down to where the pump could seize it. When the larger pumps mastered the inflow of water, production followed.

PHYSICS

Application of Spectroscopy in the Petroleum Industry—J. Reid Nielsen, in OIL & GAS JOURNAL, Vol. 40 (1942), No. 37, pp. 34, 36-37, 38.

The spectroscope has long been a tool of chemists in various industries, but its application in the oil industry is just beginning. The beginning is as yet a modest one, but the eventual possibilities appear to be large. Spectrographic analysis by emission spectra is used to determine various inorganic impurities in crude oil and helium in natural gas, and at least two oil companies use emission spectra to determine iron and other metals in crankcase oil and for testing corrosion and wear characteristics of lubricating oils and greases. Other materials spectrographically tested in the oil industry include steels, bearings, sludges, etc., and the method is applied to control t e purity and efficiency of catalysts. Two oil companies apply the method to the analysis of oilfield waters; it is also being used for core and soil analysis and in correlating geological strata. One American oil company is using ultraviolet and visible absorption spectra for routine determination of toluene in petroleum products, and this application in refinery processes for catalytic aromatization and for routine determination of hydrocarbons with conjugated double bonds (such as butadiene) is likely to grow. This phase of spectroscopy is also used to determine the transparency of petroleum oils, and for determining crude oil in drilling cores. Progress is being made in the development of suitable apparatus. Thus, an instrument has been devised which continually analyzes and records the infrared absorption of a hydrocarbon gas flowing through a cell, and is used for control of distillation.

The infrared analysis of n-butane and isobutane mixtures is in routine use by at least two oil companies. Instead of the usual low-temperature distillation method a high school graduate can make this test in 15 minutes. With a precision of 0.5%, spectroscopic methods have been worked out for analyzing various mixtures, such as isomeric butanes and pentanes and certain mixtures of isomeric octanes. Determination of total amounts of olefins and acetylene in cracked gasoline is fairly simple. The application of Raman spectra in the analysis

Holman HARD HITTING HAMMERS

PNEUMATIC

PLANT

SPECIALISTS

Holman BROS. LTD.
CAMBORNE • • • ENGLAND

Phone: Camborne 2275
Grams: "Airdrill-Camborne"

of petroleum products seems to have large possibilities. Some Russian chemists have reported work on the identification of 100 hydrocarbons in a light gasoline fraction. Italian chemists report a correlation between the Raman spectrum of a hydrocarbon and its octane number. To repeat, there is here a field that is sure to become of great practical as well as of purely scientific interest.

Simple Methods for Calculation of Theoretical Plates Required for Separation of Two Normal Liquids by Batch Fractionation—Arthur Rose, before DIVISION OF PETROLEUM CHEMISTRY, AMERICAN CHEMICAL SOCIETY, St. Louis meeting, April, 1941.

For mixtures of similar normal liquids with normal vapor liquid equilibrium relations, and in cases where the usual simplifying assumptions of distillation and negligible holdup are justified, the equations

$$n = \frac{2.85}{\log_{10}\alpha} = R \quad \text{and} \quad n = \frac{T_B + T_A}{3(T_B - T_A)} = R$$

are suggested for estimating approximately the equivalent number of theoretical plates (n) and the reflux ratio (R) suitable for a standard separation in which the first 40% distilled has an average purity of 95 mole %. The derivation of the equations is described, the limitations of such approximation formulas are emphasized, and they are compared with a correlation of more accurate Rayleigh type calculations which show that the number of plates required may be chosen from any value within a limited range, provided the accompanying reflux is properly fixed. The limits of the range of plates required and the methods of choosing the proper reflux are indicated. The temperatures in the above equations are °K and T_B is the higher temperature.

REFINING

Improved Motor Fuels Through Selective Blending—C. R. Wagner, W. R. Ross, L. M. Henderson and T. H. Brisk, before AMERICAN PETROLEUM INSTITUTE, 22nd Annual Meeting, San Francisco, November, 1941.

This is a report of progress in an investigation on the effect of chemical composition of motor fuels on the road anti-knock performance and road lead susceptibility of these fuels.

At the start of the investigation an arbitrary definition of an "ideal" fuel was set up. As defined by the authors the "ideal" motor fuel is one that will satisfy the anti-knock requirements of any engine in which it is used throughout the entire engine-speed range but which will not possess any "wasted" or excessive anti-knock quality at any speed. The recently developed borderline road-knock testing method was used to ascertain whether a given motor fuel could qualify as "ideal" in the sense of the above definition. Some 284 special fuel blends and approximately 200 commercial gasolines were tried out in 25 different cars. While the fuels were being road-tested by the borderline method they were also analyzed to determine their chemical compositions, in particular, their contents of olefins, aromatics, paraffins and naphthenes.

One result of the investigation was to show that the borderline road knock testing method brings out remarkable differences in the road behavior of different fuels—differences which the standard C F R road-test procedure does not clearly show. Among observations made with the borderline method is that of two gasolines having nearly the same motor method octane numbers, one (vapor-phase cracked) may have extremely good low-speed anti-knock qualities and the other (straight run) may have extremely good high-speed anti-knock quality. It is an obvious suggestion that if the good qualities of these two fuels were combined the result would be one that approaches the "ideal". The tests showed that the average commercial fuel has a tendency to knock at low speeds, although its high speed performance is generally adequate. Most commercial gasolines would therefore seem to need improvement in their low-speed performance.

The influence of chemical composition may be seen in these observations: The tests have shown that any fuel containing large portions of olefinic material throughout the boiling range will tend to knock at high engine speeds, and will have relatively poor lead suspectibility not only in the laboratory, but on the road. A highly sensitive fuel, however, in which the high-boiling olefins have been replaced with heavy paraffinic, aromatic, or naphthenic material will show considerably better high-speed performance and considerably better road lead susceptibility. Fuels containing large amounts of paraffinic material in the light-boiling range, in general, will have poor low-speed anti-knock performance and poor lead susceptibility at low speeds; but if the low-boiling paraffins are replaced with light olefinic and/or aromatic material, low-speed anti-knock performance and low-speed road lead susceptibility usually will be improved.

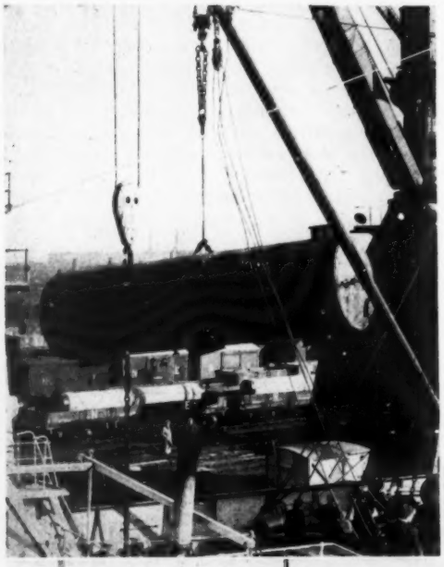
In order to give the average fuel a composition that will approach that of the ideal fuel, the following hints are given.

Substitution, in small amounts, of high-boiling paraffinic, aromatic, or naphthenic material for the high-boiling olefinic hydrocarbons normally contained in a highly cracked fuel.

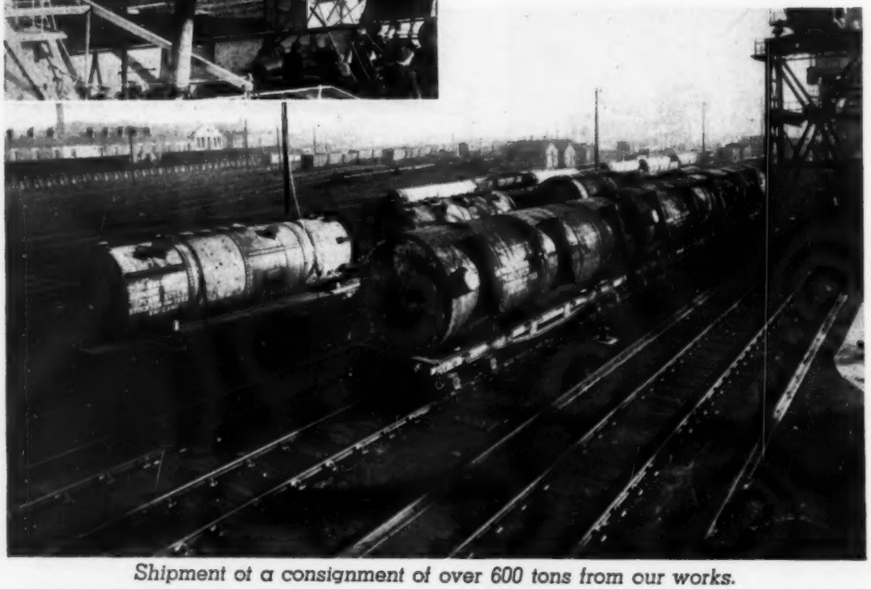
Addition of light olefinic or aromatic material to a straight-run fuel.

Blending refinery stocks with due consideration to the effect of such blending on the road lead susceptibility throughout the speed range.

MODERN INDUSTRIAL PLANT



IN
STEEL
CAST IRON
AND
COPPER
SUPPLIED
AND
ERECTED
THROUGHOUT
THE
WORLD
FOR ALL PURPOSES



Shipment of a consignment of over 600 tons from our works.

ASHMORE, BENSON, PEASE & CO. Ltd.
STOCKTON-ON-TEES ENGLAND

Using light olefinic material rather than light paraffinic material to obtain satisfactory volatility.

GENERAL

Crude Petroleum Costs—Report issued by INDEPENDENT PETROLEUM ASSOCIATION OF AMERICA, October, 1941, 39 pages.

This report presents a study of the cost of finding, acquiring, and producing crude oil in the United States. This is admittedly a very complex matter, considering that there are about 400,000 individual wells in the country producing from thousands of individual pools under an endless variety of surface and subsurface conditions. However, there are common cost problems and basic trends that affect virtually all wells and make it possible to present a picture of costs at an average well. Stripper wells which contribute 14 percent of the total production and contain 20 percent of the total reserves are included in the picture. All possible elements of cost, including the cost of dry holes are brought into the final result. The figures are summarized in the accompanying table. It is noted that investment to find and acquire new reserves has increased in five years from $6,998 to $20,091 per bbl.; investment for drilling and equipment increased from $20,826 to $20,837, making a total increase of investment from $27,824 to $40,928. No significant change has been found in operating costs per bbl. On the whole the average cost of a bbl. of oil has increased 35 cents. It is concluded that costs are now so far out of line with the price of crude oil that there is not sufficient incentive for continuation of exploratory work.

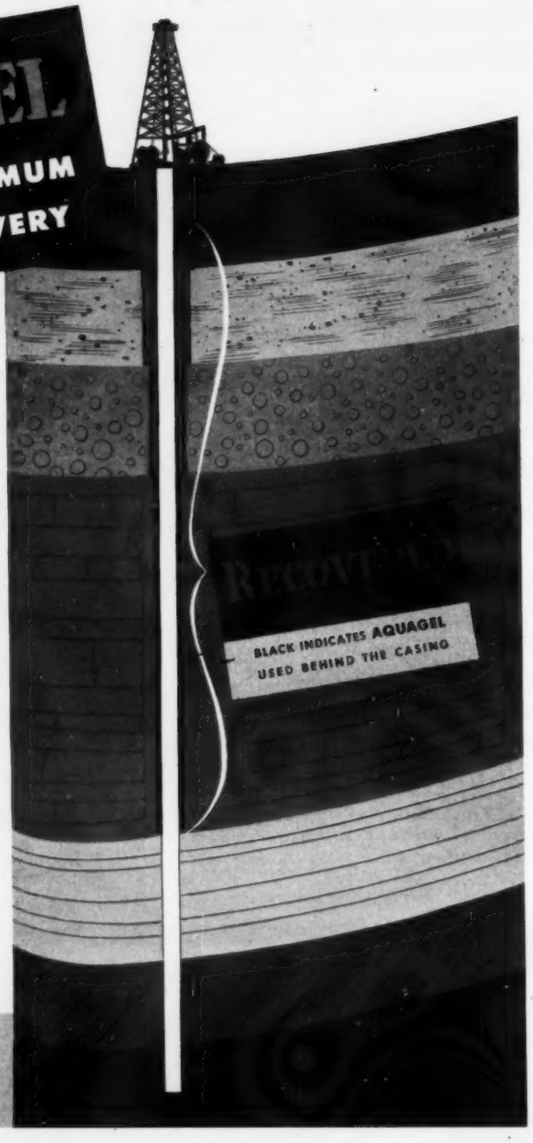
Costs of Finding, Acquiring, and Producing Crude Oil in the United States Under Conditions Prevailing for the Years 1937 Through 1941

	1937	1938	1939	1940	1941
Indicated Total Life Years	18	21	22	21	21
Total Producing Oil Wells	363,030	369,640	380,390	392,268	404,146
Av. Annual Net Prod. per Well (bbls.)	3,083	2,875	2,910	3,015	2,988
Per Bbl. Cost to Find & Acquire	12.61c	13.95c	16.71c	22.63c	32.02c
Per Well Cost to Find & Acquire	$ 6,988	$ 8,422	$10,698	$14,328	$20,091
Per Well Cost to Drill & Equip	$20,826	$20,985	$20,570	$20,725	$20,837
Total Inv. Per Well	$27,824	$29,407	$31,268	$35,053	$40,928
Per Barrel Price of Oil	$ 1.180	$ 1.130	$ 1.020	$ 1.020	$ 1.120
Per Bbl. Gas and Misc. Inc.	.060	.060	.060	.060	.060
Per Barrel Operating Cost	.336	.339	.344	.345	.347
Annual Per Well:					
Oil Revenue	$ 3,638	$ 3,249	$ 2,968	$ 3,075	$ 3,347
Gas & Misc. Income	185	173	175	181	179
Total Revenue	$ 3,823	$ 3,422	$ 3,143	$ 3,256	$ 3,526
Operating Cost	$ 1,036	$ 975	$ 1,001	$ 1,040	$ 1,037
Income Tax	13	15	5	.....	26
Total Cash Expense	$ 1,049	$ 990	$ 1,006	$ 1,040	$ 1,063
Income Before Depr., Depl. & Int.	$ 2,774	$ 2,432	$ 2,137	$ 2,216	$ 2,463
Depreciation and Depletion	1,546	1,400	1,421	1,669	1,948
Income Before Interest	$ 1,228	$ 1,032	$ 716	$ 547	$ 515
Interest @ 6%	1,024	1,100	1,173	1,311	1,531
Net Income After All Exp.	$ 204	def $ 68	def $457	def $764	def $1,016
Years to Pay Out	10.4	12.1	14.6	15.8	17.0
Annual Rate of Pay Out	9.6%	8.3%	6.8%	6.3%	5.9%
Annual Rate of Return (Financial Table)	6½%	5¾%	3¾%	2¾%	2%
Per Barrel Costs:					
a. Total Cash Expenses	$ .340	$ .344	$ .346	$ .345	$ .356
b. Depreciation & Depletion	.501	.487	.488	.554	.652
c. Interest @ 6%	.332	.383	.403	.435	.512
d. Total Cost	$ 1.173	$ 1.214	$ 1.237	$ 1.334	$ 1.520

HIGH QUALITY
STEELS
FOR THE OIL INDUSTRY.
TRADE ERA MARK
H.R.
HEAT-RESISTING STEELS
HAVE NUMEROUS APPLICATIONS.
For parts of plant requiring rigidity and low scaling loss at high temperatures they are unequalled.
TRADE ERA MARK
C.R.
NON-CORRODING STEELS
FOR THERMOWELLS, REACTION VESSELS, PUMP PARTS, BUBBLE CAPS.
Highly resistant to the attack of numerous chemical agents.
REFORMER OVEN TUBES AND FITTINGS OF HADFIELDS "ERA H.R." HEAT-RESISTING STEEL. FABRICATED FROM ROLLED PLATES AND WELDED TOGETHER. LENGTH OF TUBES 24 FEET 1¾ INCHES. INSIDE DIAMETER 6 INCHES.
HADFIELDS LTD.
EAST HECLA WORKS • SHEFFIELD • ENGLAND.
No. 2517

AQUAGEL

ASSURES MAXIMUM CASING RECOVERY



AQUAGEL by preventing caving, lubricating the formation, shutting off excessive water flows (all of which prevent freezing of the casing), enables almost 100% recovery of intermediate strings in cable tool operations. As an example, in one field alone where 40 wells were drilled, using AQUAGEL, 39 had complete casing recovery. This is many times greater recovery than when AQUAGEL is not used. Inasmuch as 39.6% of all the wells in the United States during 1941 were drilled with cable tools, the extra casing which could have been recovered, had AQUAGEL been used, would amount to many thousands of tons. In addition, less than half the time is consumed in pulling casing, corrosion is materially reduced and the life of drilling line is prolonged when AQUAGEL is used. These same benefits often apply in rotary drilling.

AQUAGEL and all other Baroid Products, promote economical, fast and safe drilling.

PATENT LICENSES, unrestricted as to sources of supply of materials but on royalty bases, will be granted to responsible oil companies and operators to practice the inventions of any one/or all of United States Patents Nos. 1,873,944; 1,873,945; 1,807,082; 1,991,637 and further improvements thereof. Applications for such licenses should be made to Los Angeles office.

BAROID SALES DIVISION

NATIONAL LEAD COMPANY

BAROID SALES OFFICES: HOUSTON • LOS ANGELES • TULSA

BAROID PRODUCTS: Baroid and Colex, Aquagel, Fibrotex, Baroco, Stabilite, Aquagel-Cement, Smentex, Zoogel, Impermex, Micatex, Testing Equipment, Baroid Well Logging Service.

CHEMICO

the leading name in acid plants

Chemico supremacy is based on 28 years of specialized experience in acid production and recovery, unequaled resources and facilities in experimentation and design, and the results obtained in hundreds of installations all over the world. Consult Chemico for either new construction or remodeling of acid plants, whether for large or small requirements.

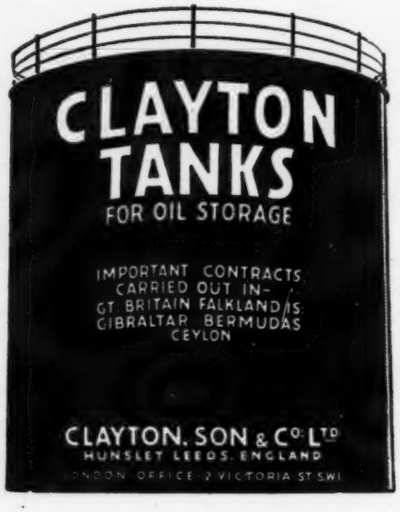
Chemical Construction Corporation

30 Rockefeller Plaza, New York, N. Y.

Cables:—Chemiconst, New York

European Representatives, Cyanamid Products, Ltd. Berkhamsted, Herts., England

CHEMICO PLANTS are PROFITABLE INVESTMENTS



Quick Rubber

(continued from page 25)

by the PIWC to advise and assist the refiners in the matter. The Standard Oil Company (New Jersey) has announced that it will be producing between 15,000 and 30,000 tons of extra butadiene from its own make-shift facilities by the first of the year.

Besides these moves to obtain "quick" butadiene another move is on foot to obtain "quick" butyl rubber, a product which has been alloted an ultimate production of 132,000 tons a year in the government's program. This government butyl rubber, like Buna S, is to be made in carefully designed plants which have received appropriate allotments of critical materials. The production of this extra butyl rubber, like the production of extra butadiene for extra Buna S, will have to be done in make-shift plants. Butyl rubber is made from isobutylene, a raw material which is available in far greater quantity than is called for in the fine plants built under the government's program. Most of this isobutylene exists in refinery gases from which only a small proportion is now being extracted for making aviation gasoline. If this isobutylene were concentrated and delivered to the rubber makers the amount of butyl rubber could be greatly increased in a short time. With this in view a detailed organization has been set up by the OPC and the PIWC to study the problem in every single refinery in the United States, large and small. Designs have been prepared for make-shift equipment for concentrating isobutylene in quantities as small as ten barrels a day.

Studies of tire requirements by economists who have gone carefully into the subject have led to the conclusion that 20,000,000 of the cars in the United States perform necessary or highly useful functions and should if possible be kept in full or partial use depending upon the occupations and locations of their owners. Rubber needs for automobile use based on the elimination of cars that are not indispensable and reduced driving and careful maintenance of those that remain in use have been variously estimated at 150,000 to 200,000 tons. As one ton of rubber will provide 170 tires an annual output of 200,000 tons aside from military needs would make available one and two-thirds tires for each car remaining in use. Whether or not the adoption of emergency methods will make possible the production of 200,000 tons outside the war program is problematical. The figure at any rate represents the maximum estimate of those who have confidence in the efficiency of the quick rubber campaign. One point strongly insisted upon by all who have studied the question of rubber substitutes is that nothing in sight justifies any deviation from the strictest care and conservation of existing tire equipment. It is pointed out that even the best of synthetic rubbers are inferior to the natural product in their resistance to heat and consequently will deteriorate rapidly.